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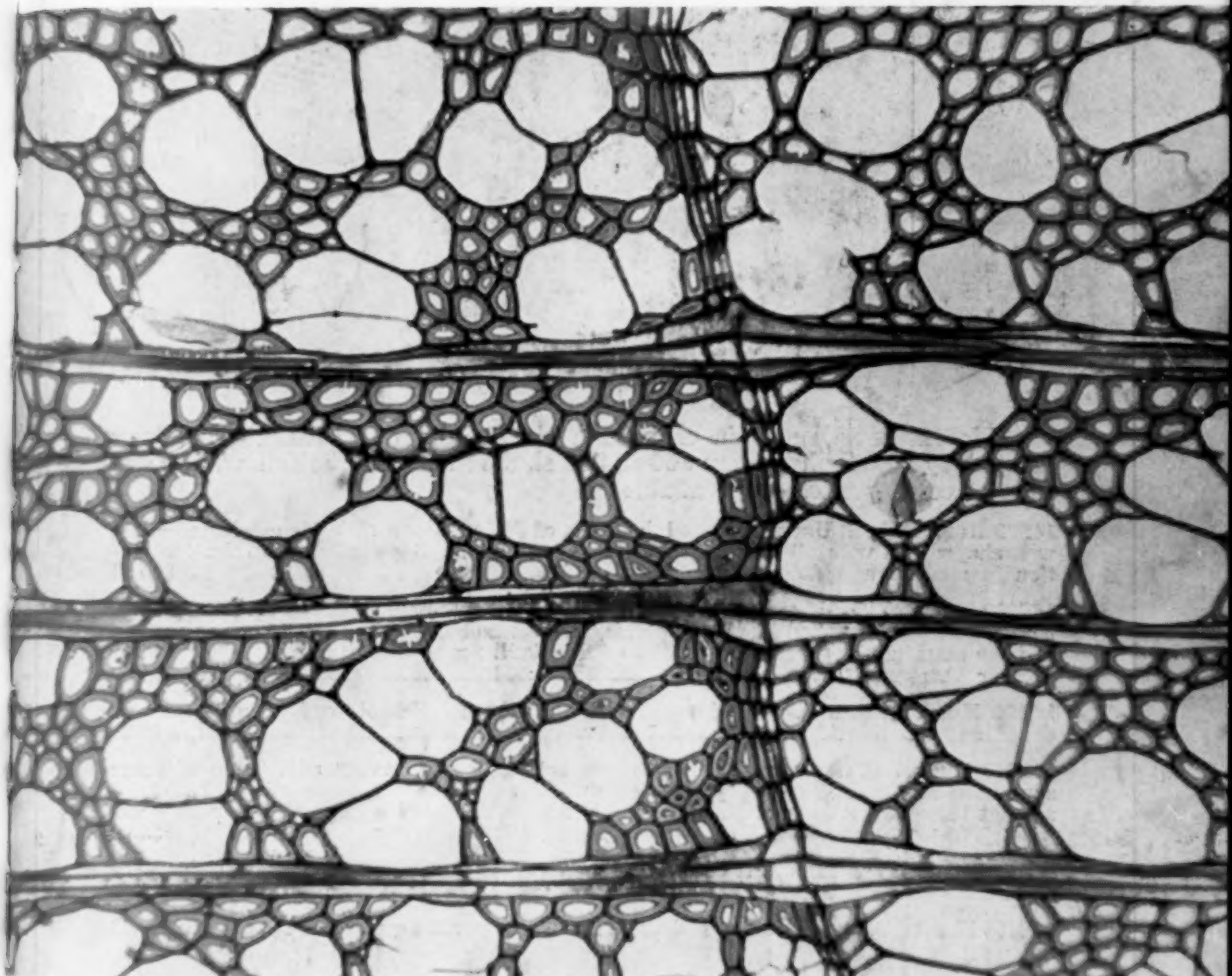

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THE AMERICAN BIOLOGY TEACHER

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Special Issue!

A bonus issue of ABT for all NABT members will be in the mails soon. It will be a special number devoted exclusively to microbiology and sponsored by the Society of American Bacteriologists and one of our loyal advertisers, Difco, Inc. This journal will be dated June, 1960, and will constitute an extra ninth issue.

Cover Picture

This is a familiar photomicrograph showing an annual ring in a cross section of *Liriodendron tulipfera.* Submitted by F. Paul Ralston, Biology Department, Ferris Institute, Big Rapids, Michigan.

Problems of Content and Level*

BURR RONEY

University of Houston, Houston, Texas; Director, Secondary School Biological Sciences Film Series of the AIBS

In the process of trying to prepare me to teach this AIBS Film Series course, the consultants have put me through a most unusual series of seminars. Obviously the consultants had to go through the meetings too, and we may already have had some side effects on the field of biology—there have been some unexpected cases of "intellectual cross-fertilization." I hope. More than once I've had the sensation of being the world's biggest idiot in the field of biology—just from listening to the things I didn't know about the field, from the experts in a particular part of that field. But my self-respect was often saved, just at the last moment, by having one of the experts look at another with surprise and say, "Well—I'll be darned—*I* didn't know *THAT!*" Who can tell—perhaps the broad science of biology will have gained just from having the experts get together and talk to each other about their fields—and biology.

Now I would like to speak about a few of the problems that I face with respect to the *selection* and *level* of content.

Decisions on *what to select* and *the level* of approach involve many, many issues. Some are practical problems, and some are so theoretical that they involve every aspect of our philosophies and convictions about teaching and learning. Let me name just a few and make some brief comments about each.

1. Who and what is "the 10th grader?" Where is he when he comes to take biology? Where is he "culturally"—if that's the word? What is his biological and mental maturity? What is his capacity? Because all this bears on—
2. Where do we begin? and
3. What do we select—(or, should we try to give him everything)?

*This article is the second half of a speech delivered at the joint NABT-AIBS Symposium, STREAMLINING BIOLOGY, at Chicago, December 28, 1959. Dr. Roney first described the general history, background and organization of the AIBS Film Series. Further information on that project may be had by writing to AIBS Film Series, 2000 P Street, N.W., Washington 6, D.C.

First—where is the 10th grader? He's so varied that it's a mistake to try to generalize too much, but I think that among the problems we must face are these:

1. In general he has reached the age of fifteen or sixteen and finished 10 years of schooling without any predictable amount of science in his background—and if he has *any*, it's usually appallingly inadequate. How he got this way is not my problem at the moment. I'm just trying to figure out where we start. And even if he has had some science, it's not apt to include much valid biology—because he lives in, and we live in, a culture that's loaded down with superstitions, with beliefs and prejudices about other living organisms, and about man himself. The teaching of biology is still restricted by the walls of supernaturalism that surround man—the highest wall—and surround other living organisms to a lesser extent.

The path of least resistance then leads us to emphasize the socially less sensitive physical sciences in the student's early training and to avoid some of the major facts of biology. This may even be among the reasons why some people feel that biology should always come after physics and chemistry. *My own opinion is that enough physical science can be taught along with biology to lead a student toward an understanding of biology itself.* As I will say again later, because understanding consists of *relationships* between facts of experience, no one set of facts about physical science promotes understanding of biology unless considered along with the facts of biology.

There is little or nothing in the knowledge of the physical sciences that *in itself* gives any insight into organisms. The physical sciences are major tools of biology, but we have to teach biology as *biology*, anyway, sooner or later.

So, for whatever reasons, 10th graders are without much background in science in general, and know even less about biology than they do about the physical sciences. However, all the evidence that I can find,

and our testing experience with our early films, indicates that a tenth grader *will* react quickly and favorably to the presentation of biology as a dynamic and experimental study.

My conclusion is that we have to be very careful not to mistake the 10th grade student's *lack of information and background* about science in general and biology in particular for a *lack of capacity* to understand when the teaching of biology begins and is properly taught. He's handicapped, but primarily he's untried. There are many factors that cause his scientifically retarded state; lack of ability is *not* one of them.

Practically, in our trying to work out the level of approach at the beginning of this course, we're assuming very little in the way of background, but we are also trying *not* to waste film time on material of extreme simplicity that can be part of the student's preparation, because there are texts, study guides, a teacher's manual, and a laboratory that should go along with the films.

Of course, many of the standard comments made about aptitudes and interests of 10th grade students are, as you know far better than I, strange examples of logic. I hear that 10th graders are too interested in sex at that age to be interested in biology! And, that I shouldn't introduce very many new words; although words are supposed to be acquired at the 10th grade age quite easily and much more easily than ideas! I've heard also that few students in 10th grade have science aptitudes, that most of them are more oriented to, or apt, in matters of language, and that these language-able students have trouble with science because of its technical vocabulary. At this point, I begin to wonder how much anybody really knows about 10th graders and what they can learn.

I'd like to repeat: Let's be careful *not* to confuse *the student's lack of background*, and *our lack of information about the possible performance of these students* with their *actual ability to learn*. That ability is probably greater than we've ever given them a chance to show.

Let's consider now the problem of beginning the teaching of biology without having much to count on in the preparation of a student. Even here we have a problem.

Cells are understood better if one understands a little biochemistry first, and, in turn, biochemistry is better understood if one knows a little biophysics, and both biochemistry and biophysics are understood best if one knows something about cells first!

There's no topic that is not better understood if some other topic is learned first. This gives me a clue to the nature of understanding. Apparently we are described as having understanding, and feel that we have it, when items of information can be *related* to other items of information. It would appear then that the way to start, is to begin anywhere, and to present a *pattern of related items of information*, first at a relatively simple *level*, but in the whole pattern; then *some* relationships will be learned and *some* understanding will result.

Of course, all we do when we learn to understand *more* is to go over the same pattern again, and then again, each time increasing the *number* of items and the *complexity* of the pattern of relationships until we feel that we understand *more* and in greater depth. I think that we, therefore, always start, not with a single first item, but with a *pattern of related facts* which can be introduced in any number of ways, as long as, eventually, the *pattern* emerges. I must admit that I pay little attention to questions about why I didn't start at one point rather than another, or to comments about how much background is needed to *really* understand a given topic. What I'm more interested in knowing, when all the main facts of a given pattern are in, no matter where I started, *is whether the relationship between them is clear and understandable.*

"Understanding" is often used as though it stood for something absolute. I wonder who *really* understands *atoms*, or *energy*, or *cells?* To me, it is more effective teaching to present, for example, the entire pattern of energy release in cell respiration four or five times, starting with a relatively simple version of the pattern and each time adding a little more to it; it is better to do that than to isolate each part of the pattern and discuss it in great detail.

The problems of level, of simplicity, and of selection of content now arise, very appropriately. There are just a few comments I'd like to make that bear on these problems.

First, in biology we include a diversity of material as great as that of all the physical sciences put together. Yet the subject is weighted in curricula as though it were the

equivalent of only physics, or only chemistry, or only geology. Our problem of selection is, therefore, very great—greater than it should be. However, this may, in the long run, be good for us as *biologists*, because it forces us to try to answer some difficult questions about fundamentals, questions we might dodge, or lose sight of if we had two or three years of biological sciences available during which we could ride our specialized hobby horses to our heart's content. It was interesting to me that a number of our consultants admitted that they arrived at our meetings expecting much of the time to be spent in hair-splitting and intra-specialty wrangling. That such did not happen was at least partly the result of the fact that we didn't have all the time in the world to indulge our pet theories. When asked, "What are the most important basic facts and ideas on this topic that can be presented in 12 half-hour films?" everyone got down to agreement on fundamentals in a very short time.

But there's more to the problem than just the way the biological sciences are all grouped under one heading. Teachers have several times commented that there's so much more to learn now than there used to be, how can we ever expect to get it all into one course? One answer to this involves the fact that we often confuse all the learning, and then unlearning, and relearning, and all the theories, and revised theories *we* have had to go through, and the whole history of science, with the fundamentals of what's actually known about biology today. I submit that it isn't necessary to learn that the world is flat, before one learns that it's round; it isn't necessary to learn that an atom was once thought to be solid, before it's discovered not to be solid; it isn't necessary to learn that it is difficult to define the term *protoplasm*, and to spend a lot of time trying to do so, before we explain that actually the word has no use, and that what we are really talking about are cells; it isn't necessary to learn inaccurate and misleading "equations" for photosynthesis and respiration when we know they aren't equations anyway, and that to call them equations is very misleading. We can teach our students now, right away, what it took us a long time to learn—that the best way to talk about photosynthesis and respiration is in sentences in which we say what we do know about them and what we don't know about them as biochemical processes. We are teaching pseudoscience if we imply by an equation a series of chemical changes with a quantitative accuracy that isn't really true. That is not simplification; it's misinformation.

I've been repeatedly shocked to hear teachers say that it's so hard to keep up to date because what one learns as *true* today turns out to be *false* tomorrow, since biology advances so rapidly. I wonder what kind of biology they've been learning and teaching that can be true today and false tomorrow? Offhand, it sounds as though they'd been memorizing the genus and species names in a very unsettled taxonomic group and calling it biology.

When the content of biology in 1960 is accurately described and pruned of historical misinformation, its fundamentals are *easier* to understand than they used to be because there are somewhat fewer mysteries about organisms than there used to be. But don't be alarmed for fear that there's no future in biology. There are still a few things that are not known! Enough work remains to keep several biologists busy for quite some time! And don't get the idea that I think there is no value in the specific study of the development and history of biological concepts. Much insight into the process of the practice of science—the nature of scientific methods—comes from the study of the history of science, but don't make your students rework every experiment and enter every blind alley that we've been through in the last ten or twenty thousand years.

This brings me to what I think is another major practice that leads to the mistaken view that the quantity of information in biology is just too great to handle. It has been said to me over and over again, "Be sure to use a *discovery* approach. Students must find out things for themselves. The essence of good teaching is to create conditions of *discovery;* don't be didactic."

My answer to this is Aristotelian, "Nothing too much." Any method can be used to excess. I suspect that much of what has been criticized about "Cook-Book" laboratories has been the practice of trying to make students repeat every experiment that has ever been done in the past. On the other hand, it is impossible to discover everything for one's self. Perhaps

part of the 10th grader's lack of background in science after 9 years of schooling has been caused by our waiting around for him to discover physics, chemistry, and biology for himself!

I gather that the main point to making a discovery as part of the process of learning has been missed by some people. The only discovery worth making as a student is the discovery that *discovery is possible*, and what the ways are that lead to discovery. To this end, highly selected examples that are particularly revealing are more important than the number of times a student has to go through the process of duplicating inaccurately the discovery of something trivial that has long been known. Students know just as well as we do that in most cases it is a waste of time to spend hours trying to find the answer to a question for one's self if the answer can easily be found by looking in the right reference book.

To the best of my knowledge, never before have so many prominent biologists spent so much time and effort to outline the fundamentals of their subject.

The problem of converting this material into a 10th grade-level biology course is a serious and difficult one. It has been more difficult to get good advice and agreement about *how* the content should be taught than it was to get agreement on the content itself. A few of the general convictions I have developed as a result of exposure to this process of "course-making," and that influence some of the decisions I've tried to make are:

—That tenth graders are more able and more competent in science than their present backgrounds in science would indicate and more able than their teachers sometimes give them credit for being.

—That there is no *single* proper point to begin the teaching of biology.

—That understanding requires the presentation of patterns of facts, of related ideas, and that these patterns should be presented relatively complete, rather than piecemeal, at the highest level the student is able to grasp rather than the lowest, and that repetition of the pattern, with all the material in context, at various levels as the student progresses, achieves more understanding than does a fragmentary method of presentation. No one achieves complete understanding after the first time around with a new subject, nor after the thousandth time around with an old one.

—That to become well-oriented in the field of biology we need an understanding of certain fundamental patterns of facts and related ideas, and that the quantity of material is overwhelming only if we cling to every bit of misinformation we ever had and try to pass it on to our students, only if we confuse many theories with the facts on which they are based, and only if we multiply examples of general principles needlessly.

—That how to go about discovering and creating more knowledge is more important than trying to discover everything for one's self, and that the *process* of discovery can be taught using a relatively small number of examples.

As an illustration of some of the problems we are trying to solve, let me briefly indicate what we have been doing with the chemistry of photosynthesis. The subject is on my mind because we recently finished one of three films on aspects of photosynthesis.

$$6CO_2 + 6H_2O \xrightarrow[\text{Chlorophyll}]{\text{Light}} C_6H_{12}O_6 + 6O_2$$

Or even this one?

$$6CO_2 + 12H_2O + \text{Energy} \xrightarrow[\text{Chlorophyll}]{\text{Light Energy}} C_6H_{12}O_6 + 6O_2 + 6H_2O.$$

Do you ask your students to memorize this equation? I hope you haven't been doing so, or that if you have, it hasn't made much impression on your students, because neither is, strictly speaking, quantitatively accurate, and both imply chemical events which are untrue. For example, water is not "added on to" carbon dioxide: actually more water (or its equivalent in ions) is involved in the chemical machinery than is indicated; the first sugar formed is *not* glucose but a form of a three-carbon sugar, glyceraldehyde; the process involves many steps, not just one, and so on.

Do you reverse the arrow and call it "respiration?" If you do, that's a mistake because the two processes are not the reverse of each other.

How did we ever happen to learn such misinformation? Probably because some one made a notation of what we knew went into, and what we thought came out of a plant cell in chemical symbols, and then turned those symbols into an equation. There never was any evidence for the "plus" signs, nor was there any evidence that the *only* requirements were

chlorophyll and light energy. What do we really know about photosynthesis? The following statements are all true, but I'm sure they do not represent all that will be known about photosynthesis some day. Depending on the level and abilities of a class, not all these facts need be taught.

1. We can divide what we know about the formation of sugar in green plant cells into two stages.

2. The first stage involves the trapping of light energy by chlorophyll and the removal of 2H's from the O of water. Chlorophyll is an energy trap that converts certain wavelengths of light (radiant energy) into chemical energy. We do not know how this happens. Some of the resulting chemical energy is used to separate the 2H's from the O, and some of it appears as high-energy phosphate bonds. We don't know how much energy is trapped. The structure of the chloroplast in which the chlorophyll is located is an important part of the process. Why, we do not know. The O left over is given off as O_2.

3. The second stage is the formation of a sugar from the H and from CO_2. This second stage requires an operating, living cell and its chemical machinery to form the sugar, it requires more water as part of the process, and high-energy phosphate bonds to work the machinery. The first sugar formed has no common name. Its formula is $C_3H_6O_3$. It is called G.A.L. for glyceraldehyde. Three CO_2's are used in forming one GAL. When it first appears it has a phosphate attached to it and is called PGAL. Two PGAL's can combine rather quickly to form the 6-carbon sugar, glucose. Glucose is more stable, and is the most common form of carbohydrate transported around the organism. But PGAL can be, and is, used directly in the respiration that supplies a plant cell with energy. Maltose and starch are larger molecules formed from glucose. Starch is primarily a storage form of GAL.

4. To summarize *photosynthesis*, we can say that in a green plant, the chemical machinery of a cell, which includes chloroplasts and chlorophyll, uses both light energy and chemical energy and forms PGAL from water and carbon dioxide in two stages, and also somehow traps part of the light energy as chemical energy in phosphates.

I think such a "verbal" presentation is more accurate and easier to understand. Believe it or not, we *are* all trying to make life simpler for teachers, rather than more complicated. You and your students will decide to what degree we are successful.

Genetics on TV

A one-semester college course on "Principles of Genetics" will be presented over education television KETC-TV in St. Louis beginning February 8, 1960. Dr. Irwin H. Herskowitz, associate professor of biology at St. Louis University, and originator of the idea for the series, is moderator of the films and also is acting as general coordinator for the genetics of the project. The series will cover human genetics, the effect of radiation upon humans, genetics and disease, and development.

The program, designed for college credit, will consist of forty-five half-hour film lectures given by fifteen of the nation's leading geneticists, including Nobel Prize winners Dr. George W. Beadle, California Institute of Technology; Dr. Hermann J. Muller, Indiana University; and Dr. Joshua Lederberg, Stanford University. "Television students" will be expected to attend nine Saturday morning sessions at St. Louis University, also. This film series is to be distributed nationally and internationally following its fifteen-week showing in St. Louis.

Irradiation Studies

One thousand white laboratory rats at Syracuse University's Biology Research Laboratory are on a diet of irradiated shrimp, chicken, cabbage, and oranges to see how animal tissues and enzymes are affected by irradiated food. This research is part of a national scientific effort to determine how irradiation can supplement current food preservation methods.

Sultana - An Excellent Classroom Plant

JOSEPH D. NOVAK
Purdue University, Lafayette, Indiana

One problem of the busy classroom teacher is to provide living material for class use with a minimum of maintenance and cost. For elementary and high school use, the material should not require daily attention (especially on Sunday!) and should be suitable for a wide variety of classroom uses. Perhaps few organisms meet these restrictions as well as *Impatiens Sultanii*, or as it is commonly known, Sultana. These plants bear flowers varying from white to orange to purple in color. They are available in most five and ten cent stores and at many florists.

Growth of Sultana

Sultana can be grown in any good garden soil, in sand with occasional fertilizer added to the water, or in tap water. When grown in tap water, it is advisable to change the water every two or three months and to add a nutrient solution (see Reference 4). When cuttings of Sultana are placed in water, roots will form in 5 to 8 days. The plants should be covered with jars, Saran Wrap, waxed paper, or other transparent material. This reduces water loss but permits photosynthesis. The cover may be removed when roots are evident. Jars can be placed on window sills or under artificial light. Plants can be maintained in water, with occasional "fertilizing," indefinitely. A profusion of clean roots will be produced and these may be used for individual or group study of root growth (see Fig. 1).

Hydroponics

Sultana is an excellent plant for hydroponic studies. Various types of nutrient solutions may be prepared varying from complete media to distilled water (see References 1 or 2). Cuttings of Sultana can be weighed and then "planted" in jars with specific nutrient medium marked with wax pencil or paper labels. Cuttings should be approximately uniform though minor differences in weight can be considered in final analysis of data obtained. Cuttings are rooted as noted above, and observations of root and shoot growth may be recorded. Plants may be removed from jars at the end of the experiment, weighed, and final observation noted.

Light experiments

Cuttings of Sultana may be weighed and then grown in jars and covered with various colors of cellophane. Gain in weight provides a measure of the relative effectiveness of various wave-lengths of light in photosynthesis. It is important to adjust light intensity transmitted through the cellophane by use of tissue paper or other "neutral" filters since blue cellophane will transmit much less light than clear cellophane. Most camera light meters can be used to determine the necessary tissue paper covering needed for equal intensity of light transmission.

If colored cellophane is not available, Sultana could be used to study effect of light intensity on gain in weight; i.e., the photosynthetic yield over several weeks. It is best to use a uniform light source (window sills can be used) and vary light intensities by varying layers of tissue paper covering. Clear cellophane should cover all plants, however, to avoid marked variations in water loss.

Students may wish to use Sultana to do special projects to study the effect of flashing light, various dark and light periods, and combination of light and nutrient variations. Tropisms can also be demonstrated.

Osmotic studies

The lower epidermis of Sultana can be mounted in distilled water and stomatal opening noted. Salt or sugar solution can be passed under the cover slip by drawing water out with the corner of a paper towel or facial tissue. The guard cells will close as water is removed. In addition to illustration of osmotic action, mechanism of guard cell action is simulated.

The epidermis of Sultana petals is easily peeled. Colored flowers will show large vacuoles with colored pigment delimiting the vacuole. As salt or sugar solution is passed under the cover slip, vacuoles will contract. Plasmodesmata are evidenced as portions of the cytoplasm "stick" to the cell walls. Varying solution concentrations can provide an exer-

cise in determining the osmotic concentration of the epidermal cell sap.

Anatomical study

The leaf and stem epidermis is very easy to "peel" from Sultana plants. To peel off lower leaf epidermis, leaves should be torn diagonally thus: hold the leaf with apex away from you. Begin tearing leaf near the apex and draw leaf margin toward you and to the side. You can obtain as much as one-third of the leaf epidermis in a single sheet of cells. This epidermis can be mounted in water for study of stomatal apparatus and other epidermal features.

The stem of Sultana is translucent when held up to a light. The vascular bundles are easily visible and branching at the nodes can be seen. Soaking plant roots in acid fuchsin or red ink for several hours will intensify the contrast of vascular bundles. Transport of solutions is also illustrated. Radioactive materials can be added simultaneously with dye solutions, and transport of radioactive material can be correlated with dye transport—a possible variation of relatively common science fair projects.

Using a razor blade, preferably a single-edged blade, thin slices of roots and stems can be made. These can be mounted in water and serve as excellent material for the study of parenchyma, collenchyma, chlorenchyma, and epidermal cells. Vascular tissues can be studied in occasional "favorable" slices. Leaves can also be sliced and palisade and other leaf tissues can be observed.

Ontogeny of leaf and stem tissue can be studied using Sultana. The shoot apex of this plant can be observed by removing most of the leaves and then slicing the apical region longitudinally with a *sharp* razor. A thin slice through the center of the apical region will show the growing point or promeristem and young leaf primordia. Axillary bud primordia can be observed at the base of some leaf primordia. Developing vascular tissue can be seen. Since Sultana forms many lateral branches, each with a usable shoot apex, one plant can provide ten or more shoots for study.

Growth of pollen

The concept of alternation of generations is often difficult to teach, especially with regard to flowering plants. Germination of pollen to illustrate the "plant" nature of the male gametophyte can help to illustrate alternation of generations. Mature pollen from Sultana will usually germinate in 2 per cent sucrose solution and pollen tubes several times the length of the pollen grains can be observed in 15 to 30 minutes. The grains can be mounted on a slide in sucrose solution and growth of the tubes noted from time to time during the class period. Students may wish to explore pollen germination as a special project.

FIGURE 1. *Impatiens Sultanii.* Plant at left grown in soil after rooting in water. Plant at right grown in tap water.

The resourceful teacher will find other uses for Sultana in addition to those noted here. In addition to the practical applications of this plant in the biology classroom, the plant is attractive. Does your biology room have *living*, aesthetically pleasant material in it?

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2. Machlis, Leonard and John G. Torrey, *Plants in Action, A Laboratory Manual of Plant Physiology*. San Francisco: W. H. Freeman and Company, 1956.
3. Morholt, Evelyn, Paul F. Brandwein, and Alexander Joseph, *A Sourcebook for the Biological Sciences*. New York: Harcourt, Brace, and Company, 1958.
4. Turtox Service Leaflet No. 51, Hydroponics: Growing Plants in Nutrient Solutions Without Soil. General Biological Supply House, 8200 South Hoyne Avenue, Chicago 20, Illinois (Free to teachers).

One cancer patient in three is now being saved, according to the American Cancer Society.

Some Problems in the Teaching of Biology*

ARNOLD B. GROBMAN
Director, Biological Sciences Curriculum Study

As many of the readers of ABT know, the Biological Sciences Curriculum Study was established by the American Institute of Biological Sciences in January, 1959, with the financial assistance of the National Science Foundation. The participants in the Curriculum Study represent secondary school biology teachers, college biology teachers, superintendents, state departments of education, medical education, agricultural education, museums and botanical gardens, university administrators, science authors, colleges of education, and other areas.

The BSCS is concerned with biological education at all levels, kindergarten through graduate school, and has begun its initial work with secondary school biology. It is planning to hold a Writing Conference on the campus of the University of Colorado this summer to design a new and improved series of courses to serve as the first offerings in biology at the secondary school level. It hopes to develop a unified study of living things in courses suitable for the majority of students in our high schools.

For those interested in learning more about the Curriculum Study, a *Newsletter* has been prepared, and copies of it may be obtained free by writing to the BSCS at the University of Colorado in Boulder.

A large number of questions have been discussed by some of us associated with the Study. At this time we would appreciate learning of the reactions to some of them by biology teachers whom we have not yet been able to contact personally. We realize that many of these questions can be answered by properly conducted investigations. We also realize that there may be no single best answer to some of these questions and that teachers of equal competence may obtain equally good results using quite different methods. For reasons of inclination, environment, or other circumstances, a particular teacher might quite properly prefer one approach to another that seems to be equally good on theoretical grounds. Thus, the reactions of practicing teachers to the following propositions would be of real interest to us. We invite comments from teachers who have given these matters serious thought.

PROPOSITION 1

A. Secondary school students are most readily motivated by progressing from the familiar to the unfamiliar. This suggests that a first course in biology could begin with human anatomy and physiology and proceed to less familiar aspects of the life sciences.

B. Secondary school students are most readily motivated by beginning with novel materials and then progressing to more familiar materials. This suggests that a first course in biology could properly begin with microbiology in which most students would be introduced to the living world of protozoa and bacteria for the first time.

PROPOSITION 2

A. Better basic understanding is obtained by treating one topic fully and in depth before proceeding to another topic. This suggests that a biology course might consist of related but discrete units such as genetics, evolution, and others.

B. Better basic understanding is obtained by introducing the same idea in a number of different places throughout a course of study. This suggests that ideas like genetic continuity and evolution be threaded throughout the course and that they appear in several different associations in a biology course.

PROPOSITION 3

A. Current journals and sources provide an adequate coverage of basic information and new developments in the biological sciences in a form suitable for secondary school biology teachers.

B. There is a need for new sources that will provide materials on ba ic information and new developments in the biological sciences

*Based on remarks given at the NABT meetings with the AAAS in Chicago, December, 1959.

specifically designed for secondary school biology teachers.

PROPOSITION 4

A. As a contribution from the BSCS, the typical high school biology teacher would prefer to have available a number of individual units, or topics, that he could (if he desired) utilize in his present course by substituting such units for portions of the material he currently presents.

B. As a contribution from the BSCS, the typical high school biology teacher would prefer to have several complete courses available, one of which he could (if he desired) utilize as a replacement for his present course.

The BSCS would welcome comments from members of the NABT about these propositions and about other aspects of secondary school biology. We are anxious to have the advice of all secondary school biology teachers who are interested, as we are, in improving the biological sciences curriculum in the American high school.

Red Tide

Possible control of "red tide"—the mysterious ocean scourge that breaks forth from time to time, often killing many fish, may be possible. Dissolved copper is "extremely poisonous" to the tiny organisms which cause the red tide, Albert Collier of the United States Fish and Wildlife Service said. Other microscopic life in the water produces substances which can counteract the effects of copper and greatly promote red tide development. Complex biochemical and biological balances in the sea, not yet completely understood, affect the growth of the Florida red tide organism named Gymnodinium brevis. It was found that the organic compounds present can combine with copper in such a way that it is no longer toxic. Thus a dense concentration of organisms producing organic chemicals may at the same time make the water less toxic to Gymnodinium brevis and provide growth-promoting substances. In addition, other organic substances not necessarily related to the above have been demonstrated to occur in sea water and to affect the behavior of oysters. These substances are carbohydrates, which include such things as sugars and starches. Experimentally it has been demonstrated that the vitamin niacinamide will influence the behavior of oysters in a very pronounced way, and very dilute solutions of ascorbic acid, the commonly known vitamin C, will induce breeding behavior in barnacles immediately on contact.

Organic compounds also provide food for the growth of bacteria, and some bacteria in the sea will produce vitamin B-12, an important growth factor for many living organisms. It has been shown experimentally that certain bacteria producing vitamin B-12 will grow in the presence of Gymnodinium brevis, but not in its absence, when a culture medium designed for Gymnodinium brevis is used. This shows how various organic compounds in the water can affect the life processes of the oceans and bays.

Nutrition

Professor Clive M. McCay, one of the world's experts on food, and a professor at Cornell University, states that the average person allows his diet to get worse in old age. He blames the decline in diet on unnecessary economy with food, dentures, poor cooking arrangements, and eating alone. There is no reason for Americans—regardless of age or income—to have a poor diet, if the money is spent in the selection of good food and the food is prepared properly.

Professor McCay is of the opinion that the best overall program for elderly individuals today is to read and study literature on foods and nutrition. At the same time, we all need to be objective in thinking of the problems of our individual bodies.

Bibliography Available

A new bibliography of PAPERBOUND BOOKS IN THE HISTORY AND PHILOSOPHY OF SCIENCE has been prepared as a guide for high school science teachers. This 16-page, mimeographed bibliography lists approximately 200 titles and includes an estimate of the difficulty of the content and language of each book. High school science teachers may obtain a copy of the bibliography by sending a request to the compiler, Leo. E. Klopfer, 73 Batchelder House, Harvard Graduate School of Education, 7 Kirkland Street, Cambridge 38, Mass. Please enclose 10¢ to cover mailing expenses.

Visual Techniques in Teaching Biology Via Television

B. JOHN SYROCKI and MELVIN SMAGORINSKY
State University of New York, Brockport

Several papers concerned with instruction via television expressed the need for an exchange of techniques of instruction. It is the purpose of this report to share with you some of the techniques and visuals concerning the instruction of general biology that were found to be effective not only from the point of view of science instruction but also with respect to their adaptability to the medium of television. Melvin Smagorinsky is the Director of the Closed Circuit Instructional Television at Brockport and B. John Syrocki a professor of biology.

General Biology at Brockport

This is the second year that a number of classes of general biology are being taught on television. In order to adapt the course in biology for television, and to set up an experimental design to ascertain statistically the effectiveness of instruction by television, the first semester of the year's course in general biology was divided into two parts: *Part I Human Biology*, taught in two lecture-demonstrations each week by television; *Part II Lower Animals*, taught during a one two-hour laboratory period each week.

Visuals for Television

A fundamental consideration in developing visuals for use on television is a regard for the way the visuals will appear when on camera. Here are but a few considerations:

1. *Proportion of the over-all visual.* In general, the proportion of the width of the visual to its vertical size is 4 to 3. This will permit maximum size of the entire visual on the screen since the television screen is constructed in approximately this ratio.
2. *Color.* In some instances different hues of colors will appear the same intensity of grey. This makes it difficult for students to see the separation as normally indicated by differences in color. For example, some shades of green and red may appear the same grey color on the screen. Some consideration therefore needs to be given to the color of visuals.
3. *Labels and lettering.* We found for our use that the main diagram should not exceed a height of eight inches. Lettering should be in black ink, and at least one inch high. This makes it possible for the lettering to appear about two inches high on a twenty-four inch screen. Black letters show well on grey cardboard. For lettering with a professional look, the LEROY scriber was used, with template 3240-500C1 and lettering pen No. 3233-8N by LEROY. Brush pens and speedball pens are serviceable.
4. *Spacing.* The visual needs to be centered when on the screen. To assure this, it is necessary to provide a margin between 3 and 4 inches around the visual.

TECHNIQUES AND VISUALS

The Flannel Board

Construction.

The flannel board proved most useful in instruction via television. A piece of plywood 30 inches wide, 34 inches long, and one half inch thick was covered with green *wool* flannel. A wool flannel provides a smooth, flat surface that retains its fine texture after much use.

Tack the wool flannel around the edges of the board. You will find that one square yard of flannel will cover the board. Nail a frame of wood to cover the nails and to protect the edges of the flannel board. This frame is made of wood one half inch thick and one and one-half inches wide. Note in Figure 1 that the board is of sufficient size to store the labels and parts of diagrams. To keep the board upright, attach a piece of plywood 12 inches square and one quarter of an inch thick to the back of the board with two hinges. This permits the back rest to swing out and hold the flannel board in place. Figure 2 shows how a piece of string holds the backrest in

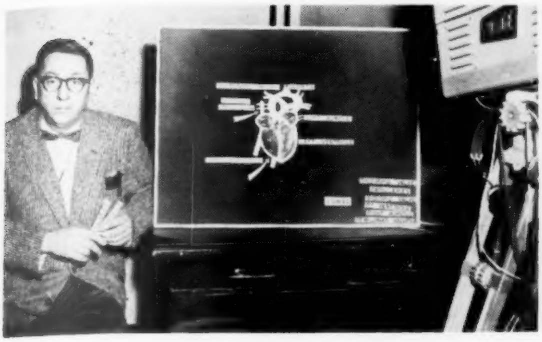


Figure 1. Professor Syrocki seated next to the flannel board to show relative size.

position. When attaching the backrest with hinges, be sure that the bottom of the backrest is level with the bottom frame of the flannel board.

The Human Heart and Blood Vessels

A drawing eight inches high of the heart with its blood vessels is made on a piece of white cardboard. Labels are made on grey cardboard. Usually the back side of white cardboard is grey. Use a speedball pen to outline the diagram with black ink. Against the green flannel, the combination of black, white and grey provides adequate contrast. The flannel on television is grey, the chambers of the heart and lettering on grey background an intense black. See Figure 3. Each label and drawing is backed with wool flannel. Spread *rubber cement* generously over the back of each label and drawing and put them over a piece of flannel. Press firmly and cut off excess flannel with scissors.

During the telecast, students are given dittoed drawings of the heart. Space is provided for inserting labels as the heart is discussed. Drawings of the heart are for student use.

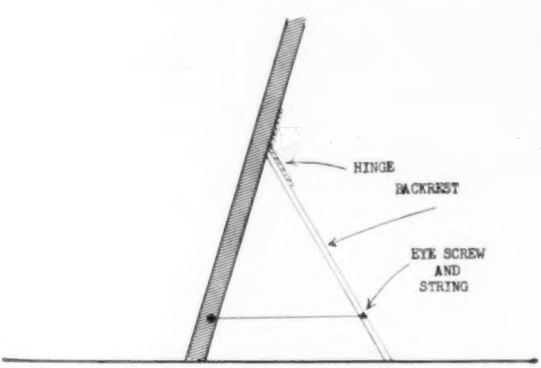


Figure 2. Side view of flannel board.

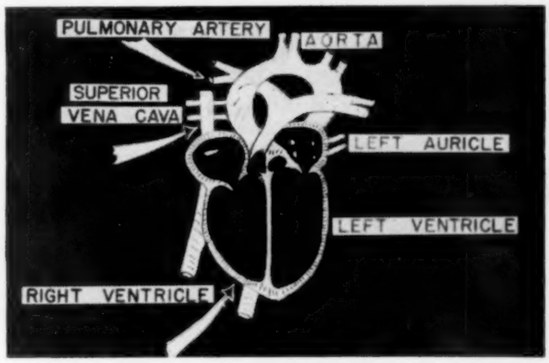


Figure 3. Diagram of heart and blood vessels.

The Human Ear

Lecture-demonstrations on the ear were partly conducted using the flannel board and a model of the ear. Make the drawing of the ear as shown in the photograph. Cut the drawing into the following sectional parts: the outer ear and its canal, the tympanum, middle ear and its ossicles, cochlea, semicircular canals, and the auditory nerve. See Figure 4. Students in the viewing rooms were given drawings of the ear. Labels were entered as the discussion of the ear proceeded on television. Sectioning of the diagram of the ear permits progressive development of concepts concerning the structure of the ear.

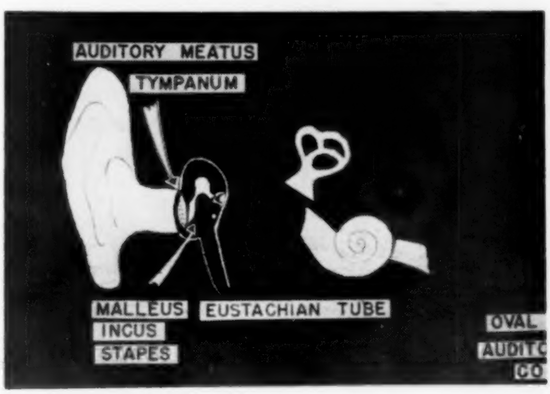


Figure 4. Sectional parts of ear.

Review of Vocabulary

Obtain a large piece of firm, grey cardboard. Cut out a rectangular opening 3 by 13 inches as shown in the illustration. Frame the cut-out in black with a brush pen. Place the cardboard against the paper on the crawl, and

write in the word. The *crawl* consists of a roll of paper mounted on two rollers. Turning one roller, winds the paper on the other roll. A commercial crawl board is shown in Figure 5.

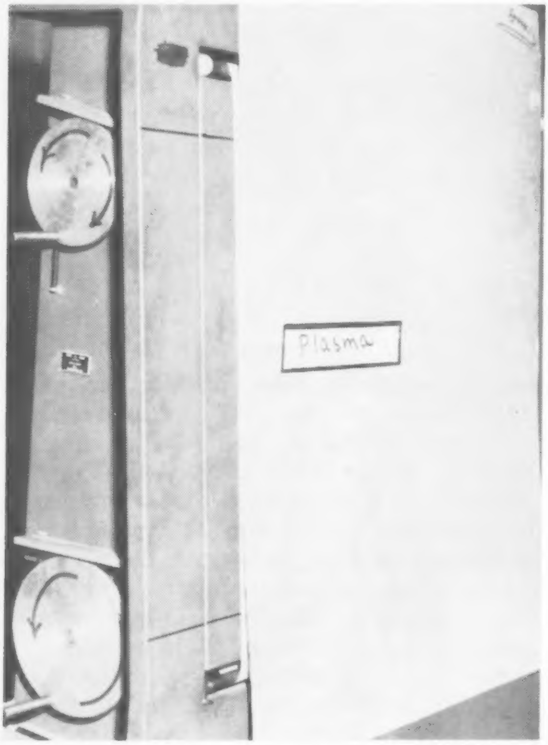


Figure 5. Side view of crawl with cardboard in position to show single words.

After writing one word, turn the roll and write the next word. Continue to roll the paper until you have written half the number of words you are planning to discuss. Reverse the cardboard so that the opening is now on the right side of the crawl. This utilizes the right side of the roll of paper.

This technique permits the instructor to concern himself mainly with the discussion of the vocabulary since the words are all written in advance with a brush pen. Flashing the words one at a time enables the instructor to maintain the attention of students on one particular word without possible distraction of other words in the list. Interest in words yet to appear on the screen is maintained.

Repainting Models

To utilize some colored models, it was necessary to repaint them. The scheme of black, white, and grey colors was used. The human heart model was painted with striking effects and appeared most effective from an instructional point of view on television. Chambers of the heart were vivid, and valves were easily demonstrated. When painted black, the walls of the chambers as well as some of the arteries and veins photographed in good contrast, especially when held against a background of grey cardboard.

Three-Dimensional Mock-Ups on Television

In some instances, mock-ups in third dimension are more striking than flat drawings. In discussing pulmonary circulation, plastic coated bell wire was used to simulate blood vessels. Small cut-outs of the lung and heart were given depth by mounting them on small pieces of wood one half inch thick mounted in proper position on a piece of grey cardboard. Paint the chambers of the heart white and the walls and valves of the heart black. In extreme camera close-ups, the black wires entering the left auricle, or the wire leaving the right ventricle makes the blood vessels look real. Two wires from each of the lungs will lead to the left auricle, the one wire from the right ventricle branches into two wires to show a branch of the pulmonary artery going to each lung. To show the branching effect, remove a tiny bit of wire insulation and attach at this point another wire so as not to show any bare wire. Paint the area black.

An Electric Pointer for Use with Filmstrips

Whenever a filmstrip is projected for a telecast, there is a need for some type of pointer in order to make specific reference to parts of a picture during a discussion. A number of different types of pointers were tried out. Here is a pointer that was found most useful for this purpose, and it is homemade. The filmstrip is projected on a screen in a darkened studio. In another part of the studio, the instructor uses a pointer with a small flashlight bulb at one end of the pointer. On contact the bulb lights up. This light when picked up by another camera and *superimposed on the picture* then shows up as a white spot. The support for the pointer does not show since it is used in front of the green flannel board or a piece of black paper in a darkened studio. To locate the part of the picture to which you wish to point, mark off

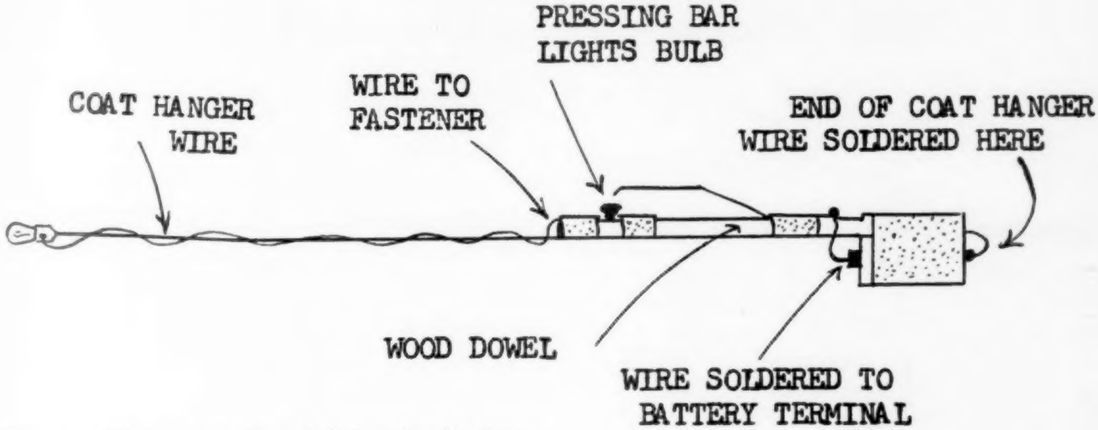


Figure 6. Diagram to show full length of pointer.

an area on a piece of black cardboard equal to the size of the picture on the screen in the studio. This will help you to approximate the position of that portion of the picture to which you have reference. This will also reduce the amount of stray lighting by the pointer. For emphasis, the light may be put on and off several times to call attention to a specific part of a picture.

Construction of the Pointer

Obtain a heavy wire coat hanger and straighten out a piece 25 inches long. Affix with adhesive tape, on top of one end of the wire, a piece of wood dowel 7 inches long and one half of an inch in diameter as shown in Figure 6.

Solder the base of a GE 14 type flashlight bulb to the tip of the other end of the coat hanger wire. Take a piece of plastic coated bell wire 23 inches long and solder one end to the side of the light bulb. Wrap the bell wire around the coat hanger wire up to the wood dowel. See Figure 7.

Wrap the end of the bell wire around a large paper fastener and solder, using rosin core solder. Spread the ends of the fastener over the wood dowel and attach firmly with turns of adhesive tape. Attach a strip of brass or steel spring one half of an inch wide and 3 inches long as shown in Figure 8 for the handle of the pointer. Attach a flashlight battery to the wood dowel with several turns of adhesive. Solder a piece of wire from the center terminal of the battery to one end of the strip of metal. Solder the curved end of the coat hanger wire to the bottom of the battery. On contact of the strip of metal with the fastener, the bulb will light.

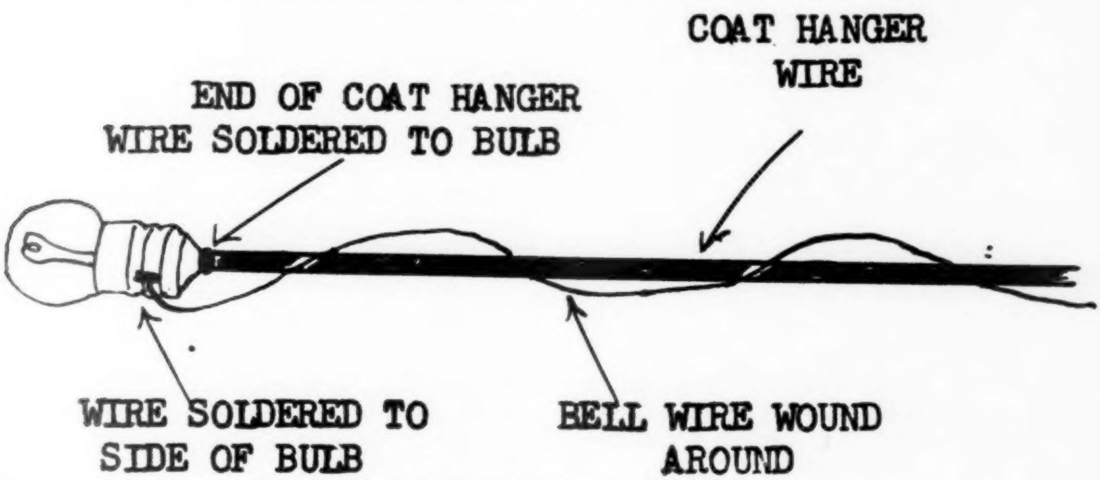


Figure 7. Close-up to show details of bulb connection.

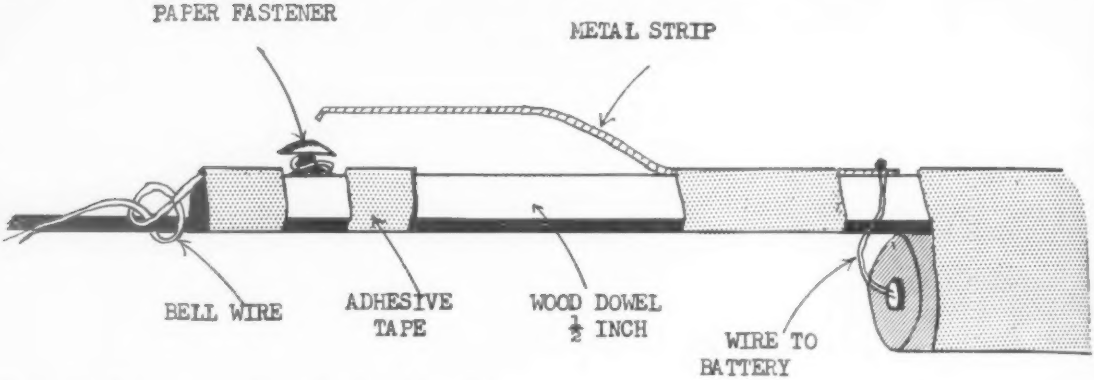


Figure 8. Close-up to show details of handle.

Synthetic Proteins

By recreating in the laboratory conditions that existed on the primitive earth, two chemists at Florida State University have produced a material that "can be regarded as synthetic protein." The new product—which closely resembles natural protein in chemical behavior and is readily attacked by meat tenderizer—serves successfully as a food for bacteria and is being studied as a possible future source of synthetic food for human beings, with applications in space nutrition, according to a report by Kaoru Harada and Dr. Sidney W. Fox.

It will now be possible to make artificial proteins in great variety, comparable to nature's multitude of protein products, which include hair, nails, wool, silk, leather, hormones, enzymes and many other materials, it was indicated.

"One goal will be the production of proteins of superior nutritional quality by inclusion of high proportions of lysine, tryptophan or methionine, which are often the essential amino acids most seriously lacking in foods," Dr. Fox observed in an interview.

As long ago as 1955, Dr. Stanley L. Miller of the University of Chicago reported in the *Journal of the American Chemical Society* that he had produced amino acids by mixing together the gases that are thought to have been present in the earth's early atmosphere and exposing them to electrical discharges, simulating lightning and the effects of heat and other forms of radiation. He succeeded in making some of the amino acids most familiar in protein.

The second step, assembling the amino acid units into a protein substance, has now been accomplished by a relatively simple method—heating the proper mixture of amino acids together for 3 hours at about 350 degrees Fahrenheit, Dr. Fox explained.

"It has been known for over a century that only tars and unwanted products result from heating amino acids," he continued. "But we have learned that the reaction goes to 'synthetic proteins' if an excess of two amino acids, aspartic acid and glutamic acid, are included in the mixture."

Attention: New York City Biology Teachers

Free copies of field trip work sheets in conservation and evolution, 1959 revisions of the American Museum of Natural History work sheets, are now available from the Museum. The conservation topics cover mainly New York State conditions and include: pond community, soils, crop rotation, successions, forestry, and wildlife. The work sheets are based entirely upon the exhibits in the Museum and can be completed in one day's visit to the Museum. The evolution series covers the famous exhibits of prehistoric life at the Museum. Contact Mr. Sol Taylor, Biology Coordinator, Thomas Jefferson High School, Pennsylvania and Dumont Avenues, Brooklyn 7, New York.

The Biology Teacher, Animal Health and Disease in the Space Age*

D. H. FERRIS, *University of Illinois, Urbana*

To delimit this subject to manageable proportions this paper is concerned only with major aspects of animal health and disease in the next ten to twenty years, particularly as they may affect the biology teacher.

How important does the public consider biology in the space age? A particular American answer was given to this question when the first Sputnik was orbited. Salaries of all government employees directly concerned with the physical sciences were immediately raised. Those concerned with the biological sciences (including medical and veterinary medical doctors) were not raised until strong protests were made. There can be no denying that during the past decade or so the biological sciences have been eclipsed by the physical sciences.

Although major developments have taken place in biology during the recent years which may someday be judged as epochal, the twin satellites of nuclear fission and space exploration have cast a deep shadow on biological advances at least in public recognition and understanding. Unfortunately, even though an eclipse is temporary, and in few ways changes the basic structure of the thing shadowed, there may be unfortunate side effects.

One of these side effects is the comparative loss of public support. Another is the loss of capable young minds. This is stated, not in envy, but in admiration of and gratitude to the physical sciences. It is well recognized that biology itself, although a more complex portion of the scientific spectrum, is a part of physical sciences.

The physical sciences have started the space age with tremendous public support and interest. By their achievements and good public relations they have wrought a miraculous change in attitude toward all sciences. Consider, for example, mathematics, physics, and astronomy in 1900. These were considered dull subjects to most youthful scholars and highly abstract or theoretical subjects by businessmen. Biology, on the other hand, was fighting a valiant crusade for new concepts in evolution, genetics, and microbiology.

Microbiology, at first stoutly resisted by many of the profession, had begun to transform medicine. Nothing in the history of man can compare with the gift of health and longevity which this profession has made to the human race. But the true source of this blessing has eluded all but our keenest minds. The scientific status of medicine, a part of the biological complex of sciences, has always been related to the milieu of concept, theory, and knowledge which forms the basic biology of any given period.

What is the relationship of basic research in biology today? First, we need to consider science generally.

Nearly everyone is in a position of practical leadership, "yes, but's" any basic research. It is for someone else. Certainly it is not for practical men with immediate problems.

Few of our political, business, or industrial leaders have an inkling of the necessity for fundamental research in solving our burgeoning problems (12). Confidential questionnaires initiated and summarized by the National Science Foundation show that less than 2½% of the research dollar of industry is spent for any form of basic research (11). Even the federal government which actively publicizes its interest in basic research spends less than 3.75% of its research funds this way. Actually, as Fisher (6) has shown by a study of research publications from industry, the 2½% is too high. Much of the so-called "basic research" is directly related to the immediate concerns of the company; this is particularly true of the pharmaceutical industry, in which both small and large companies are forced to do "basic" research to remain in competition. Truesdall and Dunn (13) point out that the universities, traditionally the seat of basic research, are all

*Dr. Ferris is Associate Professor, Department of Veterinary Pathology and Hygiene, College of Veterinary Medicine, University of Illinois. This paper was given to the NABT meetings with the AAAS in Chicago, December, 1959.

too often forced to abandon this pursuit because of lack of funds; many industries try to make them a testing ground for their products.

An amazing change has taken place in a few of our larger industries—all of these, it should be noted, with roots deep in the physical sciences. These companies are spending, according to Berland (1) and Fisher (6), 15% or more of their research budget upon "blue sky" and "green grass" investigations. The investment has paid off. Berland states that careful study has shown that the returns on this money invested have been 100% to 200%. Major differences are revealed from a study of the advertising of 30 to 40 of these major companies as compared with that of industries resting on bases connected with biology. Figures 1, 2, and 3 are composites of a few of these ads. Letters from these companies revealed that they are planning a still greater emphasis upon basic research in the future.

Over and over again the theme is sounded: "Creativity," "Fundamental Research," "Imagination," "Scientist wanted to work on problems of their own choice," "Freedom to explore," "Thought," "Abstract Thinking," "Basic research is the reservoir for all advances." That these are not mere slogans is evidenced by the "cash on the barrel-head" philosophy back of these ads. These leaders are convinced that basic research pays.

NOTHING OF THIS MAGNITUDE HAS YET OCCURRED IN THE BIOLOGICAL SCIENCES. One will search in vain for this kind and amount of support by companies forming the biological counterparts of these industries. Osmosis has not yet taken place. One need only go to the great pharmaceutical houses, stock breeder's associations, gigantic food producing and processing industries, and agricultural complexes and ask for similar support for basic research. Instead, quite understandably, one finds advertising and attitudes which deal with the narrow and specific cures or ecomonic gains from the use of a certain product.

Fundamental research is for someone else! One must talk to many representatives of both types of industries to realize how completely different are the attitudes of these two sets of leaders in our western economy. References from many sources could be cited in support of this thesis. Wright (16) has pointed out that our nearly complete dependence upon Europe for advances in basic medical science. The original theoretical work on the antibiotics, all of the major pesticides, and the chemotherapeutic agents for control of parasites came from Europe. Dr. T. Keith Glennan's (8) remarks concerning Space Age science in general is even more pertinent to medicine and biology:

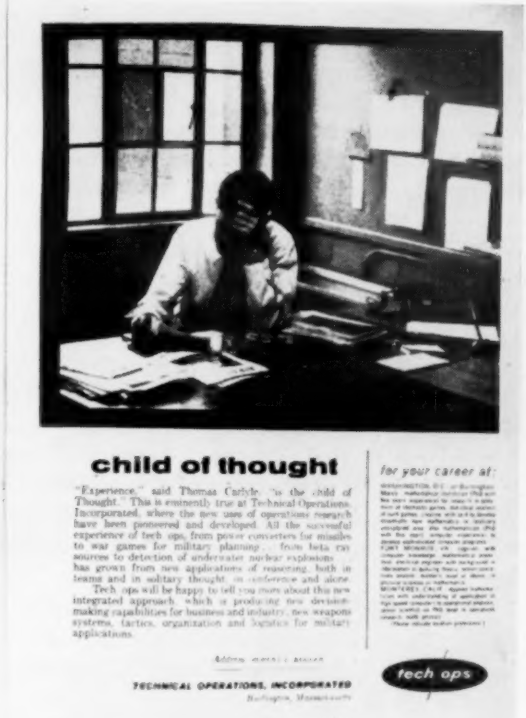
"We in America are prone to boast about our technical knowledge. I have long felt that we may have achieved this excellence at the expense of basic research. But I think the Space Age—young as it is—has already gone far toward correcting this situation. If we are to survive technologically and spiritually, we must constantly refill the reservoir of knowledge by respecting and supporting basic research."

Both in the east (where Lysenkoism is not yet dead) and in the west we start the space age attack on problems of disease and health in a piece-meal fashion. Which of the major sciences are dealing with these problems?

Both human and veterinary medicine are concerned with problems of space medicine. Since animals have led the way into space and in all aspects of future research will play a big part, it is only natural that veterinary medicine is rapidly becoming an indispensable part of the space program. Just as human medicine interprets findings in relation to man, so veterinary medicine is required to interpret adequately the physical reactions of animals. These problems directly connected with our space probes are listed by Campbell and Roos (3) under seven headings:

1. General ("Man in Space," "Space Medicine," "Men, Rockets, Space Rats")
2. Sealed Cabin Problems
3. Acceleration/Deceleration
4. Fractional and Zero Gravitation
5. Cosmic Radiation
6. Survival Problems
7. Psychological and Social Problems

Even though the physical sciences have taken the lead, the biology teachers should not let problems of space remain in the physics class. These problems are meaningful only in relation to living things. All of our science and technology is brought to bear upon the possibility of putting man and his living allies out into space.



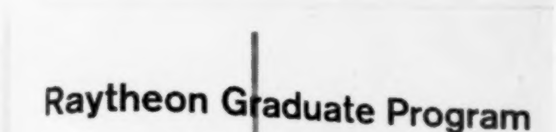


Figure 1. Examples of industrial support of basic research in the physical sciences. Each of these ads requests applications from scientists interested in doing fundamental research.

Unfortunately, the biologist has not communicated well in the past decades. The public mind, already convinced that basic research is for the crackpot, has relegated biology to the study of such trivia as worms and butterflies. Most biology teachers will admit that many students find the subject not only trivial but boring as well.

The biology teacher who enlarges his vision to include natural relationships of health and disease in the space age will find a tremendous source of vitality and strength. These are obviously not trivia. They cannot be boring to the sensitive and responsible citizen. Too often biology has been taught in a way which is unrelated to the challenges, hopes and fears of mankind. As an example of the relationship of classroom biology to space medicine we will explore only one problem of this new field.

Perhaps the major phenomenon which will affect all men in the space age ahead is that of "crowding." Whether in the cockpit of a high altitude plane, a space ship, a colony on the moon, or a nation with a high reproductive rate the *lack* of suitable space will be a common problem. Even in the absence of parasites and infectious microbes, crowding can cause disease. We are somewhat aware of problems of pollution and starvation following overpopulation. We may also be aware that all species must have peculiar specific environmental requirements, such as that of the giant condor for trees struck by lightning upon a cliff (to enable an unimpeded soaring takeoff) and a safe place to digest his prey (so that he can become light enough to become airborne after eating).

Recently, it has been shown that unlimited crowding can cause disease, even in animals which are used to close quarters. Christian (4) found that in mice and Norway rats adaptive endocrine changes took place where crowding alone was the causative factor. Even though excess food, water, nesting sites, and all other known requirements were furnished, birth rates and infant survival declined with an increase in population. Enlargement of the adrenal cortex and a decrease in the size and function of the gonads took place. There was failure of lactation with decreasing size of offspring.

Natural population explosions continue to take place, such as the enormous increase in voles which took place in California and Oregon in 1957. As many as 8000 to the acre were counted. Pasture, crops, and bales of hay in the field were eaten by the rodents. We are all aware of the fire ant. In the Middle West we are now learning about the soybean cyst nematode. Birds, machinery, and man can serve as carriers. Cost of decontamination is around $100.00 an acre—prohibitive to the private individual. It can be terminated only by going out of bean or legume farming for several years. The steady progress of oak wilt disease and the Dutch elm disease reveals our basic inability to cope with biological forces. Our vaunted chemical controls often leave us worse off than when we started.

But there are more forces of disease than the serious ones associated with crowding together of one or more species. The voles of Oregon spread tularemia; wells were contaminated, and the disease spread to predators. Crowding has always been associated with parasitism and infection. We are used to thinking only of the crowding of a single species. But man will continue to share his environment with animals, friends and foes. Each 25,000 increase in population requires a veterinarian to care for the pets with whom we associate. And there are with us still the pigeons, starlings, mice, rats, and mosquitoes. No matter how man changes the face of the earth the forces of evolution will continue. He must take cognizance of them or face some unpleasant surprises. It is not impossible to have a pleasant environment with abundant wildlife. The amazing comeback of the deer (5) in much of America has shown that natural selection is a powerful force.

Man is also anthropomorphic in his ideas about disease. Infectious disease is a parasitic phenomenon, whether the parasite is a tick, a worm, a bacterium, or a virus (2). These agents have no respect for man's superior social status. The zoonoses, as the diseases transmissible between man and animals are known, are many and caused by varied organisms. More than 100 are known with over 40 being found in Illinois. These agents move by many and devious routes from one species to another. Rabies is carried by bats, foxes, skunks, and opossum as well as our familiar cat and dog. Trichinae may be found in nearly all

Figure 2. Examples of industrial support of basic research in the physical sciences. Note the unqualified interest in basic and creative science.

wild animals as well as in pork. Human tuberculosis and brucellosis of bovine origin, by a great veterinary medical campaign, have nearly been eliminated. With a let-up on the part of the veterinary medical profession there could be an upsurge of these diseases. The zoonoses do not have a one way pattern. The great influenza pandemic of 1917 introduced the virus to our swine, and there it has remained in the form of one or more mutants where it yearly causes great losses. Even our well-scrubbed city neighborhoods cannot escape the zoonoses. Roueché (10) records in humorous vein the true story of the rickettsial pox epidemic which frightened an upper middle class section of New York City in 1946. An alert amateur biologist suggested that mice and their mites carried the disease and helped public health authorities carry out the investigation which cleared up the mystery.

The biology teacher needs to become a more active member of the team safeguarding health in the space age. Too often animals are studied as specimens in the biology class, preserved, lifeless, with hardly a thought of disease entering the discussion through many observations and dissections. Yet the condition of health is a dynamic balance with potential or active disease always present.

The teacher needs to become better acquainted with the specialists of his profession, the plant pathologist, the physiologist, the bacteriologist, the medical, and veterinary medical doctor. Since the biologist works so much with animals, he will find that the latter is a natural ally and companion. The biologist conducting experiments or doing graduate research will find that the counsel of the veterinarian is invaluable regarding the status of his controls and experimental animals. The care of laboratory animals has become a specialty of the profession; most large hospitals and research institutions now employ full time veterinarians to supervise the laboratory stock. Another specialty of the veterinary profession is gnotobiotics (9), or the science of "germ-free" animals. Institutions are springing up all over the country where animals are derived by Caesarean birth and hand-fed in a pathogen-free environment. The biologist will find it necessary to keep abreast of this work and may like to try his own hand at it.

Many biologists are finding adventure as members of epidemiological teams. Research on equine viral encephalitis, vesicular stomatitis, and other diseases has been done by biology teachers, sometimes during the summer months. Members of such a team with skills in entomology, herpetology, and mammalogy have aided in isolating zoonotic viruses from insects and other wild animals.

While the biology instructor will undoubtedly gain much from his association with the specialists of his field, this is a two way street, and he has also much to give. The biological point of view is much needed in medicine today and will be ever more so tomorrow. He has the opportunity to be the statesman of science. In spite of our gadgetry and love of chromium, Americans are not a scientifically minded people. Historians consider that we are much more like the practical minded Romans than the ancient Greeks. We have misread much of our history. Although Edison did far more basic research than we realize, he represents the American ideal of the practical inventor more than the truth-seeker and scientist. Few have realized how near America, like France, came to failure at the Panama Canal because, from President Roosevelt down, our leaders, political, business, and medical did not believe that mosquitoes carried yellow fever and malaria! The previous success of Gorgas in Cuba was looked upon by the intelligentsia of the period as an example of the success of American cleanliness over filth. Without military authority in Panama, Gorgas had a difficult time overcoming prejudices and concepts of his business supervisors which did not fit the new era.

The biologist stands between the physical and social sciences. More high school and college students take biology than any other science, and even with the newly aroused interest in mathematics and physics, this is likely to continue. If we are to face up to the needs of the space age in competition with the scientifically oriented peoples of other nations (7), biologists must do a more dynamic job of teaching than they have done in the past. Surveys made during the past ten years show that even such a fundamental concept as evolution is satisfactorily taught in less than a third of our schools, while the biology classes of over a third hardly mention it.

Future events which are around the corner will undoubtedly again focus the spotlight on

Figure 3. Examples of industrial support of basic research in the physical sciences. In the fine print, the DuMont ad stresses that "vision" lights the way to progress. All of the ads in these figures stress the opportunities open to college graduates for research in the physical sciences.

biology. The first event might well be the synthesis of self-replicating proteins in the test tube (creation of life). If evolution has been a stumbling block to our theology, think what the creation of life will do! The picture of Faust, the scientist in league with the devil, the mad scientist of space fiction, is very firmly planted in the minds of millions. When I suggested to a class that I had never known a scientist like this, a student came back with a note from his mother suggesting that I read a book called "Frankenstein" for the facts! That this was fiction did not enter the minds of this class, nor could they easily be dissuaded. We have a big job of educating ahead of us.

A second big event will be the exploration of our outer space itself. Here a tremendous question awaits the biologist: life in outer space! Whether there is life or not, the biologist will be in the spotlight. If life exists in outer space there will be decades ahead of classification and comparative biology with attendant light being undoubtedly thrown upon our own origin and upon philosophical and theological matters. If there is no life found there will be repercussions, too. Perhaps men will look again at Schweitzer's principle of "Reverence for Life." Another byproduct of space research, which will make even the most abstract research of day-to-day importance is the solution of our "lebensraum" problem. As Vogt (14) stated, even the biologist becomes concerned with the potential of life to out-grow its environment. Scientists have become cynical over the prospect of medical advances causing even greater disasters. Space research gives us the rationale for unlimited advances, even as the discovery of the New World revitalized Europe. It is hard to believe that there will not be more real estate in the vast universe. Even if power becomes available which will make interplanetary travel possible, it is hard to conceive that many of us will be making use of it. "Adscriptus glebae" (bound to the soil) may well describe most of us. But for those left on earth there will be tremendous hope. If science can make colonizing of the moon or Mars possible, how easy it will be to make any portion of this old pear shaped earth—be it desert, or tropic, or polar region—"blossom as the rose." What a great time to be a biologist.

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New Opaque Projector

An all new opaque projector, the AO Spencer Opaque 1000 Delneascope, as announced by American Optical Instrument Division, has better lighting, sharper picture, more efficient cooling system and easier operation than previous models.

Problems of Teaching Evolution in the Secondary Schools*

DAVID C. EVANS
Wilson Joint Schools, West Lawn, Pennsylvania

My invitation to participate in this panel discussion indicated that I discuss some of the problems of teaching evolution in the secondary schools. After a period of deliberation I decided that I could discuss the above topic most effectively and realistically by combining the following three resources: (1) problems which I consider prevalent, (2) through past and recent conversations, the experiences and problems of other high school biology teachers, and (3) summaries of appropriate evolutionary articles.

Keeping in mind that this topic is to be presented in a limited yet informative manner I find it convenient to subdivide these problems into two categories:

[1] General problems—this area includes laws or policies of the respective state, county, or school district, prejudices exhibited by the local community or teacher, and the relatively poor background possessed by the average biology instructor for the effective teaching of the subject of evolution.

[2] Specific teaching problems—this area includes questionable methods of presentation, areas of evolution in which there is little emphasis, and troublesome phases of evolution for the biology teacher to "get across" to his or her respective students. In my opinion, two of these troublesome phases would include the intangible eras of the geological timetable and the inevitable question of evolution and religion.

It is an established fact that today, even though many authorities claim that the controversial issue or dispute between Darwinism and Christianity is over, there still exists in several states laws which prohibit the teaching of evolution in schools, colleges, and universities supported by public funds. In other states where legislative action has failed to curtail the teaching of evolution in public supported institutions, arbitrary action has been taken by governors, state superintendents of public instruction, and city or county boards of education. In some areas textbooks have been deleted from preferred lists because of their reference to the term evolution or even the name of Charles Darwin. In fact there are several excellent high school biology texts with which I am familiar that do not mention the word evolution yet they discuss the subject quite thoroughly. One excellent biology text is used by many high school biology teachers, including myself. The term evolution cannot be found between the covers of this book, but a discussion of evolution may be found under the heading of "racial development." Obviously the publishers have sales in mind when some of these so-called forbidden terms are substituted for more acceptable terminology.

It is not uncommon to hear stories of teachers who have either lost their position or have been so intimidated by the general attitude of the local community on the question of evolution that they have voluntarily forfeited their supposed right of freedom in teaching and are studiously avoiding the subject. A personal friend of mine was granted a monetary bonus from his respective school district because of his excellent first year job in teaching biology. Shortly thereafter he was approached by two members of his school board and informed that if he expected to receive similar rewards in the future, he should eliminate the teaching of evolution from his course of study. On rare occasions I have heard reports of teachers showing prejudices by trying to "jam" evolution down their students' throats, and likewise others having no time for evolution thus disregarding its discussion completely. In an article that I read recently, it was reported that evidently

*Presented at the joint session of the NABT and the American Society of Zoologists of the AIBS at Pennsylvania State University, University Park, Pennsylvania, August 31, 1959.

some biologists have the attitude that evolution is passé, not very important in this day of modern biological developments; while others believe that since the concept of evolution is generally accepted by educated people, the presentation of the evidence for the concept to each generation of young people is not very important. Regarding the last few statements, I am happy to say that this apparently is the unusual attitude and not a common practice among the high school biology teachers.

The problem of a limited background for the effective teaching of evolution is a very common characteristic possessed by the average high school biology teacher. This characteristic is not too hard to visualize when you consider the fact that only 59% of the biology teachers have a college major in the biological sciences. A study published in 1942 by the Commission on the teaching of Biology of the Union of American Biological Societies showed that even then less than half of the high school teachers of biology taught evolution as the principle underlying the development of all living things. It was found in that study that some of those who failed to teach evolution did so because they themselves had not been well enough educated to recognize the truth of it. In my opinion, this limited background actually creates a fear in teaching evolution due to its unnecessarily controversial nature. I often wonder if the authors and publishers share this feeling of fear with these teachers and conveniently place this unit in the tail end, a characteristic of most high school biology texts. As a result of this unique position along with the yearly "running out of time factor," the cautious teacher now has an escape from teaching evolution by saying "Well it's too bad we didn't have enough time to finish the textbook." This lack of background problem has been realized in the past few years, for now many colleges and universities offer programs for inservice training of teachers of biology in order to build up the breadth of training necessary for teaching such synthesizing topics as evolution.

Turning our attention to specific teaching problems, there appears to be one problem which is considered basic by some biologists. I am referring to the manner in which the subject of evolution is presented. After many conversations with other high school biology teachers I am convinced that the average teacher does not mention evolution until he reaches the unit. It is strongly felt by some, including myself, that this treatment of evolution is definitely wrong and therefore a problem. The scope of evolution is much too vast to be confined within a single unit's discussion. If the instructor were to point out in other appropriate units the available evidence showing that organisms have become more complex through the ages and that plant and animal populations have changed with time, I am sure that when the unit on evolution was discussed the student would have a greater appreciation and understanding of the theories and the mechanisms involved in this process. It has been suggested by some biologists and biological committees that evolution should be the central theme of the course. I believe that this suggestion is designated for the advanced biology course and not the basic biology course that is usually taught in the 10th grade. However, I'd like to relate a recent experience which makes me feel that perhaps this suggestion is worth consideration even in the basic biology course. At present we have our football squad at a nearby camp for a two-week training program. Two or three days ago while walking to our practice field I became involved in a discussion with one of my potential guards who had just moved into our district. During our conversation I asked him if he enjoyed his biology course at his previous school and if he were planning to take my advanced biology course this coming year. He said that he liked his 10th grade biology course very much but for three quarters of the year he was lost with the numerous similarities and differences of various organisms, and it wasn't until the discussion of evolution that he began to "put the pieces of the puzzle together."

There are some areas of evolution that are not emphasized by many biology teachers, and many of these can be accounted for as a result of an insufficient background. One of these areas which is not emphasized enough is the historical background of evolution. Many courses of study reveal that only three or four names are usually associated with evolution—Darwin, Lamarck, De Vries, and sometimes Wallace. I feel that in order to give the students a clearer understanding of the growth of evolution, the instructor should include the

contributions of other men such as Spallanzani, Needham, Pasteur, Redi, Buffon, Oparin, and Haldane. By including the efforts of these men, the student should also be able to visualize just how the dispute between Darwinism and Christianity arose. Another area which is not emphasized enough in high school biology is the hereditary mechanism and mutations in relation to natural selection. The student cannot begin to comprehend the concept of natural selection proposed by Darwin unless he has a good foundation in the nature of the genes, how mutations occur, and the effects of a diversified environment on these mutations. With this background the high school biology student should have a more desirable appreciation of the various forms of plant and animal life. There are other areas of evolution that could be emphasized depending more or less on the calibre of the biology class, but due to the limited time, and the fact that we are interested in the average biology class, I will not take time to discuss these areas.

The last area of discussion includes some of the troublesome phases of evolution for the biology teacher to "get across" to his or her respective students. As was mentioned earlier, one of these is the intangible eras of the geological time table. It is not difficult to understand why this is a troublesome phase to get across to high school students when even mature adults cannot comprehend ten thousand years, let alone a million or a billion years. In the past few years I have found it helpful to myself, if not my students, to use the film entitled "In the Beginning" along with descriptive articles which trace the history of the earth on a 24-hour scale or a year long motion picture.

Another troublesome phase that is characteristic of all high school biology classes arises when a student raises his hand and asks, "But doesn't evolution conflict with the Bible?" In my opinion, along with the opinions of many other high school biology teachers, this is the most difficult topic to discuss in high school. In the first place, the average biology instructor is not a student of evolution nor theology; hence, it is difficult and sometimes dangerous to discuss this question with impressionable 14, 15, or 16 year old youths. Secondly, due to legal limitations, the question cannot be analyzed completely. I am referring to the fact that even though many states allow evolution to be taught in the classroom, many of these same states possess in their laws a statement or two to the effect that there should be no comments made regarding the implication made by the Bible.

In conclusion, there is no doubt that the teaching of evolution in the secondary schools is a tough assignment and, in my opinion, only an experienced, well-read, open-minded instructor can handle this task effectively.

New Use for Chlorophyll

Two classes of chlorophyll compounds, called chlorins and rhodins, have proved beneficial to laboratory animals with induced heart failure, according to Dr. Herbert W. Wetherell Jr., assistant professor of physiology and pharmocology in the University of Nebraska College of Medicine. The effect has been demonstrated many times on the hearts of frogs, rats, rabbits, and dogs, he said, emphasizing that the materials are not yet ready for testing on human beings.

The activity of these materials on the heart has been studied for some time, according to the speaker. In the new work the differences among such chlorophyll derivatives as meso-chlorins, porphyrins, and vinyl porphyrins were examined, he said, adding: "While the experiments are still a long way from clinical trials, we are nevertheless quite enthusiastic about the results.

"We do not wish to imply that eating large quantities of vegetables rich in chlorophyll, such as spinach and beat greens, is good for one's heart. The materials we have studied are derived from chlorophyll which has been subjected to several complicated laboratory procedures." Chlorophyll offers a challenge to scientists because it represents one of the principal substances occurring in nature which have not yet been synthesized, Dr. Wetherell explained. New infrared techniques developed to investigate the complex chlorophyll molecule indicate that its components are packed so closely together that they crowd each other. The fact that the crowding forces one of the parts to be bent out of its normal position suggests that duplication of the material in the laboratory would be difficult, he observed.

Horseshoe Crabs

JOSEPH L. PARKHURST, JR., *Colonia, New Jersey*

"Monoculus. Most of this genus are small aquatic insects, scarcely discoverable but with the microscope; some few are large, and the largest of the Insect tribe, is found in this genus, the M. *polyphemus*, which has been known to measure two feet in length, exclusive of the tail; in those species, said to possess only one eye, (from whence the generic name,) the two eyes are so approximated, as to appear single." These descriptive notes are included in a small volume dated 1817, "The Naturalist's Pocket-Book," compiled by George Graves, F.L.S., of London.

Before the nineteenth century horseshoe crabs were considered curiosities of nature, even giant aquatic insects, and remained unclassified for some time. A characteristic feature of these animals, the tail spike, must have suggested the Greek Xiphosura (swordtails) as a fitting name. They were placed next to spiders and scorpions in the textbooks when a certain resemblance was noticed; the head and thorax are fused.

Possibly the most descriptive name for them would be "saucepan fish," as Thoreau indicated in his journal of a Cape Cod tour. They are usually called horseshoe crabs, horseshoes, or horsefeet, with reference to the shape of the head section. Its name, *Limulus polyphemus*, hints at some sort of one-eyed monster, but there are actually two pairs of eyes. The head and eyes of this ancient sea remnant are discussed briefly in Dr. A. G. Mayer's "Sea-Shore Life," published by the New York Aquarium. "The large lateral eyes are easily seen, but if we look more closely we will also see two little median eyes farther forward. Altogether the appearance of the head region of the horseshoe crab is quite similar to that of the trilobites which died out in the age of the coal, although the trilobites probably had no median eyes."

Small limuli collected from tidal debris in the winter months.

Mating pairs after dark.

When you turn over one of these odd creatures on the beach the tail spike comes up and the gill plates open and close like pages in a book. Right side up the animal seems to move with a lurch using the last of six pairs of legs as pushers while the others help lift the bulky shell. Smaller invertebrates occupy the backs and undersides of these sluggish crabs as "mobile homes," especially double-decker snails and moss animals.

Horseshoe crabs may be seen during the spring tides in late May and early June, swarming in pairs around bay shores and digging nests in the sand. From these large depressions miniature horseshoes crawl away after hatching, although some of the eggs are washed up in the tide wrack. The same beaches are lined with bits of thin-shelled clams which the limuli grind up and eat, along with the shells of stranded crabs left for the gulls.

A stranded specimen covered with double-decker snails, *Crepidula fornicata.*

Cancer

In the frantic search for a cancer cure, is enough attention being paid to the fundamental questions "What is cancer?" and "What causes it?" Many authorities think not, according to an issue of *Chemical and Engineering News.*

About one hundred million dollars will be spent on cancer research this year, a large part of it for screening thousands of chemicals for their activity against various types of cancer in mice. The government's Cancer Chemotherapy National Service Center alone will screen more than forty thousand compounds. Past experience indicates that, for every thousand chemicals screened, only one or two prove active enough for testing in human cancer cases, the report comments. To date the entire search has yielded only about twenty drugs suitable for general use, and these show no better than temporary relief from spreading cancer and leukemia (cancer of the blood-producing organs).

Why does cancer strike some people and pass others by? How does cancer become resistant to drugs? Why does cancer incidence vary so much with geography, race, sex, age, and social and economic status?

The best way to get answers to such questions is to pour more brain power and money into basic research in biochemistry and applied scientific fields, according to several authorities interviewed.

Dr. John R. Heller, director of the National Cancer Institute, when asked what he considers the greatest need in cancer research, said:

"We know that one out of three cancer patients is being saved. We believe that, if all patients are diagnosed and adequately treated at the earliest possible moment, the rate can be raised to one out of two, using only existing knowledge."

Advanced Biological Science in Large Secondary Schools

JERRY P. LIGHTNER, *Great Falls High School, Great Falls, Montana*

Within the past decade increased attention has been focused on advanced level courses in the secondary school curriculum. Of these, advanced biology has received much consideration.

What is meant by advanced biology? A host of interpretations have been given to it. Journal, magazine, and newspaper articles most commonly use the term to denote a second-year course having General Biology as a minimum prerequisite. Some schools have additional requirements, such as: a grade average of A or B, teacher recommendation, student interest, and completion of a course in chemistry.

There are, however, other meanings. Through the use of the track system, an enriched first-year course is sometimes called advanced biology. Courses such as human physiology, health, and conservation, which may serve to broaden the surface but not to probe the depths, also use the term. Finally, some senior science courses where the student may emphasize biophysics or biochemistry may use the title of advanced biology.

The results of a survey just completed on the prevalence of advanced biological science course offerings are most interesting. This was a nationwide survey of all public secondary schools with enrollments exceeding 1000 students and all non-public secondary schools having 70 or more graduates as listed in an Office of Education bulletin.[1]

Ninety-four per cent of the 1217 secondary schools surveyed responded by postcard to the question, "Does your high school offer an advanced biological science course (such as Advanced Biology, Microbiology, College Biology) which *requires as a minimum prerequisite* the successful completion of a course in General Biology?" Table 1 shows the affirmative response to this question and the number of such courses offered by each secondary school.

TABLE 1

NUMBER OF ADVANCED BIOLOGICAL SCIENCE COURSE OFFERINGS PER SCHOOL

Number of Courses	Frequency
1 course	227
2 courses	36
3 courses	10
4 courses	2
5 courses	1

It is apparent from Table 1 that 276 large secondary schools representing 22.6 per cent of the schools sampled include at least one advanced biological science course offering in their science curriculum. The majority of schools offer only a single course but the range is from one to five courses.

A wide variety of advanced biological science course offerings was reported. Table 2 lists the courses most frequently given and the number of large secondary schools that offer each one.

TABLE 2

ADVANCED BIOLOGICAL SCIENCE COURSE OFFERINGS IN LARGE SECONDARY SCHOOLS

Title of Course Being Offered	Number of Schools Offering the Course
Advanced Biology	106
Physiology	40
Zoology	35
Biology II	28
Botany	22
Biology 3 & 4	13
College Biology	13
Biology III	11
Human Physiology	10
Human Biology	9
Anat. & Phys.	9
Lab. Techniques	8
Bio. Techniques	4
Life Science 2	3
Other titles	31

In addition to the 14 courses listed in Table 2, 21 courses with other titles were offered by 31 schools. These included Landscaping,

[1]Mabel C. Rice, *Directory of Secondary Day Schools*, U. S. Department of Health, Education, and Welfare (Washington: U. S. Government Printing Office, 1957).

Marine Biology, Nature Study, Health, Bacteriology, Field Biology, Biology Seminar, Home Technology, Conservation, Microbiology, or other very closely related titles.

Regardless of whether their school offered an advanced biological science course of any type, biology teachers across the nation expressed much interest in them. Hundreds of comments were voluntarily penciled on the margins of the reply cards. Teachers repeatedly said they favored addition of a second-year biology course or that their students had often requested it. Lack of space resulting from 100 per cent scheduling of rooms was frequently given as a reason for not being able to offer it. A score of secondary schools reported that an advanced biological science course was either going to be offered for the first time next fall or was in the planning stage for future inclusion in the science curriculum.

The following are typical of other comments made by teachers when answering the question posed to them on the reply card.

Minnesota: "All well planned schools should have Advanced Biology."

West Virginia: "School officials are not interested—a terrible handicap."

Michigan: "I gave one last year after school for no credit."

New York: "We did not find results warranted continuing Advanced Biology."

Pennsylvania: "Have been offering Advanced Biology for 25 years."

Illinois: "Our junior college course is open to qualified seniors."

South Carolina: "Plan to add it next year."

Connecticut: "No! Reason? Why specialize?"

Wyoming: "Had to drop Advanced Biology due to crowding of facilities."

There are five courses listed in Table 2, being offered by 171 large secondary schools, that are of particular interest to the author. These are Advanced Biology, Biology II, Biology 3 & 4, College Biology, and Biology III. By title it would appear that they include some truly second-year courses exploring many areas of biology in much greater depth. Some of these are of college calibre; for example, the Advanced Placement Program courses. Some are not. Nevertheless, over 14 per cent of the nation's large secondary schools offer them.

As a result of their prevalence a study is now underway to ascertain the status of these courses. Such areas as aims and purposes, principal textbooks used, course content, teacher preparation, and student research are being surveyed. This study should be completed in the fall of 1960 and the results will then be made available to teachers of biology.

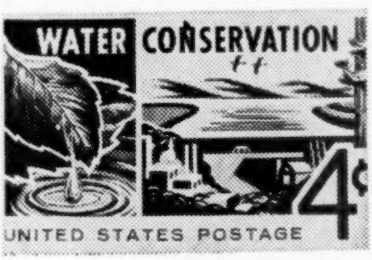
S.O.S.

The article by David Kraus and Eugene Stern in the February issue of ABT on "Carrot Tumors" mentioned that the required bacteria were available from the New York Botanical Garden. This is not the case. They have been swamped with requests for these cultures, but they are available from the American Type Culture Collection, Washington, D. C. as well as from commercial biological supply companies. Here is another evidence that the readership of the ABT is indeed a wide and alert one as the New York Botanical Garden cannot keep up with the demand for the cultures which have been requested as the result of this article.

New Stamp

This is a black and white reproduction of the 4-cent water conservation stamp now on sale at post offices throughout the country. The stamp, printed in three colors, went on sale in Washington, D. C., at the Seventh National Watershed Congress.

The unique two-part stamp portrays a close-up view of a drop of water falling from a leaf, which symbolizes the influences of land and vegetation upon water supply. This design leads the eye into a right-hand panel depicting an actual small watershed panorama. People and industries in the town in the foreground are dependent for their water upon the watershed above, which ideally includes conservation-managed farm and forest lands and small dams for flood prevention and water storage.



The Spreading Spark of Life

OSCAR RIDDLE, *Plant City, Florida*

Is a suitable synoptic view of organismal advance on earth's surface now available to teachers of high school biology? The nineteenth century contributed vastly to descriptive biology. But the insights gained by quite modern biology of the source and sequels of self-duplication (replication), of an understanding of the major and truly meaningful behavior patterns of organisms, and of the physical reasonableness of life, now take high places in the story of the advancing (changing) organism. The clear need for a brief survey giving emphasis to this triad of newer core insights provides the reason for this article.

Life is not a thing, nor entity; it is a group of intricate, localized, and erasable processes which, while not erased, tends to preserve and extend itself. Life is the expressed function of, and is unknown apart from, organism. An organism is the total sum of an integrated molecular structure and of the persisting properties of that structure; these latter include both self-maintenance and self-duplication. Organism is a thing—one readily sees and examines it. But organism can now be found solely near the very surface of the earth. And life, at its now known minimum, is the sum of those processes and properties existing in intricate organized units (organisms) which can achieve maintenance and self-reproduction from simpler materials drawn from the outer terrestrial environment.

The identity of at least one substance present in the living system that has the property of self-duplication along with that of replicating a *change* in its own structure was learned by following the backward trail of the mutation. The substance primarily involved in mutation has those properties; and the compound chiefly involved in mutation has been traced, progressively, to nucleus, chromosome, gene; or, in chemical terms, to nucleoprotein, and to nucleic acid. The semi- or quasi-living viruses—which are capable of mutation and, conditionally, capable of self-duplication—are also nucleoproteins; and in them too it is the nucleic acid component, not the protein, that is paramount. In all known organic compounds superior to viruses both the genic material and the products more intimately associated with it are so intimately organized or integrated that the term "living" is applied to that aggregate as a whole. At present, biology seems not well prepared to resolve a question such as: Is genic matter "more" alive than protoplasm?

It is both convenient and useful to digress momentarily from this area of life and organism. Their characteristics, defined above in terms of biology, clearly exceed anything that is now familiar in physics. Unavoidably, the question arises: Do the biological conclusions violate any physical law? The answer is No. In nature there are apparently two different "mechanisms" by which "orderly" events can be produced. Present-day physics utilizes the "order-from-disorder" mechanism in a successful description of events in the overwhelmingly predominant nonliving world. But topmost physicists suggest that another mechanism, new but not alien to physics, is required to deal with the "order-from-order" principle displayed by events in the organism. Beyond the complexity of its components, the organism clearly shows its quite special stature both in the concerted or harmonized activities of these components and by the uniqueness of their capacity for self-reproduction. Here, in the area of biology, we meet a phenomenon and concept as fundamental in its nature as is any of today's concepts in physics. Familiar or conventional physics, including of course its superstructure, chemistry, is nevertheless fully expressed in the isolated events within organisms; it there provides methods of approaching and comprehending those events. The phenomena of life or organism involve items such as heat, light, sound, electricity, motion, and potentials; physics deals competently with them, just as it has dealt successfully with the physical basis of sensation. Similarly, life involves chemical processes of known kinds. Finally, the principle of the conservation of energy applies as rigidly to the living world as to the universe outside it. The living cell or organism can no more produce energy than it can produce matter out of nothing.

Heredity is implicit in self-reproduction. But if self-reproduction were always and absolutely accurate there would be simple life, though there could be no other form of self-extension; there would be no heritable variation and no evolution—there would be no road to higher plant or animal. However, on our planet, the materials and conditions associated with life and self-reproduction are such that eventual variation is apparently always linked to organism. And this variation—which can now be hastened and multiplied by man—is random, blind, and indeterminate, harmful and advantageous; it is both bad and good.

This inaccurate heredity—continued through ages and always subjected to natural selection and some degree of accidental multiplication and dying out of lines has spread and lifted most life much above the one capital property, quality, or capacity of self-reproduction. But only favorable inaccuracies (variations; mutations) have any power to lift; some of the more harmful mutations are erased by death, while others less harmful and more numerous are kept and tolerated. Evolution therefore results from occasional lucky mutants which happen to be useful, not harmful.

That prolonged spread of self near our earth's surface has been both general and diverse rather than limited to any class or single groove. At least two main lines or types of life arose early and have persisted as plant and animal types. Within those types further self-expansion followed in unequal mode and degree, and over many diverging routes. It is within the animal type that biology meets the immense and chief problem of behavior—ultimately, the foundations of sight, of choice, of thought, of purpose—as part of its task of dealing with the eventual diversity attained in the living world.

Before scanning further the nature of that divergence one notes a special pattern of behavior that is widely shared by both plants and animals. Certain rhythms of activity have been imposed upon most classes of organisms, bacteria conspicuously excepted, by motions and relative positions of earth, moon, and sun. Standing alone, this fact is neither challenging nor surprising. However, many of these rhythms have shown a perplexing tendency to persist appreciably after removal or reversal of the factors—light, darkness, high or low temperature, etc.—with which they are more obviously related. And for long this dilemma has asked insistently for an explanation. Though the subject remains inadequately explored, quite recent studies have shown that at least one group or type of these geophysical rhythms, called living clocks, involve both a triggering environmental factor and a now identified endogenous factor. Familiar rhythms related to the solar day include "sleep" movements of bean and potato leaves, periods of spontaneous activity in many animals, and wakefulness in man; others are related to tide, season, etc. Many such clocks are affected and seemingly controlled by factors such as light, temperature, and barometric pressure. Nevertheless, with these several factors maintained at constant levels in a series of higher and lower plants and animals, it was recently found that metabolic rate, or rate of oxygen consumption, is the long sought and more basic source of the several geophysical rhythms thus studied. These metabolic rhythms are also ultimately geophysical in the sense that they are imposed by a broadly inclusive environment, but more directly they are based on genes. In the several organisms thus tested it is the persistence of this metabolic rhythm, following a discontinuance or reversal of the minor or triggering factors, that explains this behavior.

The preceding account shows, incidentally but most significantly, that neither of the two large divisions of earth's broad spread of life, nor high nor low status within those two divisions, has failed to utilize and clearly record a force exerted by distant and inanimate moon and sun. Knowing this it is with more expectancy than surprise that we meet facts from the vast areas of ecology and paleontology. Many physical changes on the earth's own surface or in its waters—localized in space or time—as well as localized changes in the fauna and flora, may locally modify both individual self-expansion and species survival. Nothing could be more logical than to find that the spread of self, in all past and present organismal history, has been conditioned by the principles of ecology.

Resuming the interrupted consideration of the nature and consequences of the divergence expressed in plant and animal types, one recalls the familiar fact that plant cells became specialists in the capture and storage of

energy; animal cells the ready consumers and releasers of energy. Though appreciable amounts of energy were doubtless being stored in forms such as aldehydes and organic acids in the waters of the young earth, prior to the one or many origins of the living molecule or compound, the speed and volume of such storage was vastly increased in those selves that developed an agent of the chlorophyll type. Cells thus equipped capture much energy from the sun's rays, expend part of it on the conversion of carbon dioxide to sugar or starch, and store the remainder within the structure of those products. This superior performance of the plant cell provided the basic supply of food—of energy—that has been continuously seized and utilized by the animal organism and by plants deprived of chlorophyll.

Among plants, the spread of self—the subject of this sketch—comes near to revelry or to riot. In the tree, the self acquired amazing bulk, profuse flower, and heavy fruit, yet all of these and more have been denied to the trillions of generations, and to the numberless modest selves, of bacteria and fungi. These latter are aberrant types; they are eminent sources of both help and harm to an earth crowded with more complicated organisms. This plant world nowhere fails to display all of the organization essential to self-duplication, sometimes including all of the intensely biological processes involved in the reconstruction of self through embryogenesis, but plant life remains the forever silent and voiceless area of the living world. Taking no step toward the capacities for communication involved in the teamwork of neurone and muscle cell, that world spreads neither toward voice or instinct nor to flight or thought, but it became earth's prime display of exposed and varied surface, and its unrivaled arsenal of potent molecular invention and production. The chief agents or tools utilized in the latter specialty seem simpler, and more readily outlined, than corresponding ones in the evolving animal. Most meaningful here is the increasing wealth of enzymes, and these, as in animals, increase along with the genes, perhaps in a one-gene to one-enzyme relationship. These genes, or their associated enzymes, basically determine the type and relative quantity of whatever the plant invents, along with the plant's final disposition of the product, and they also determine the organism's response or lack of it to one or another of the geophysical rhythms reviewed above. Highly significant, too, is the long list of "growth"-promoting substances or hormones—substances usually chemically unrelated to those producing comparable effects in animals.

A digression. Clearly it is the rooted or roving organism within our reach or neighborhood that is most accesible to inspection and biological study. And true also that many casual handlings of good assemblages of those species may touch almost none of the insights under review in this article. Unless text, teacher, and laboratory use the specimen as incentive and path to unseen process and principle, just what is it that the student is doing and learning? Can student or teacher, in high school or college, assume that biological *science* is being taught when the student is gaining no comprehension of the precise forces that have led to the living world as we now find it, including human existence as it earlier was and now is? If this is now unattainable in one year of tenth grade biology, what is our right response to that fact? Again, could the final ten pages of today's textbook of high school biology do better than present a suitable synoptic view of the subject, partly to guide and support the teacher and partly to guarantee to a neglected earnest student at least that one open window to an undiluted science? It should, of course, have been the purpose of many parts of the book to present an aspect of this view, but at the end it should all be tied together.

The lift of inaccurate heredity within the mobile and sensitive *animal* world was even more diverse, and immensely more creative and meaningful. There the origin and evolution of nerve, muscle, and gland became the fruitful source of the truly marvelous and meaningful expansions of self. There the promising neural fibril, always absent from the world of plants, appeared in lower members of the Metazoa, and, in some higher classes of the swollen world of invertebrates, a plenitude of fibrils (neurones) connected effector muscle and gland with the modest clusters of neurones present as dispersed and meagre brains. Within these latter classes, and closely associated with the complexity of their neural and muscle cells, the great gifts of avoidance and choice—even that of flight—

were sometimes added to the initial, precise, tranquil, delimited, and firmly localized capacity for self-duplication.

At least three or four of these relatively gifted types had spread over land or sea prior to perhaps a half billion years ago. Indeed, we can now observe that all except one of those types had then already attained their maturity; that is, they had reached a stage of specialization and loss of plasticity that precluded further extensive changes and permitted only minor ones. The one exceptional type—elongate, segmental, bilaterally symmetrical, with internal supporting or skeletal (notochord) tissue, and a brain minute but anterior—was a representative of the chordate (vertebrate) type. Some of the varying descendants of this more promising type were likewise capable of little further change, and such persisting rare species as the thin and less than fingersized *Amphioxus* permit us to regard the unseen earlier parent as a lowly, free-swimming, fish-like organism. That parental type had acquired a pattern of tissue, organ, and function—of auspiciously advanced structure and roving habit—which was destined to be adapted and progressively modified into and through a few aggressive classes—classes that would later virtually dominate all animal life on land, sea and air—fishes, amphibia, reptiles, birds, mammals.

One next recalls the nature and the main sources of the superb mental capacities unfolded by inaccurate heredity during this progression of animal life from something slightly lower than lowest fish to highest mammal. For that purpose, a hundred-fold expansion of this text could serve the reader well, but that would far exceed both the present objective and the limits imposed by this journal. Though this rich and technically complicated area of neurophysiology and anatomy must here be skirted rather than entered, this survey should not fail to record the circumstance that fewer than one *professional* biologist in fifty is now passably schooled in the techniques and existing information which illuminate the motor and mental acts of man and other primates. Few, therefore, adequately assess such cogent conclusions from modern neurology as the one noting that there are no mental "states," only mental acts.

At the level of the entire free-living cell a basis for both excitation and conduction exists in the protoplasm. Whatever the so-called neuromotor system of ciliate protozoa may turn out to be, it apparently is not a precursor of the nervous system; in protozoan cells, as in other cells, excitation of the surface appears to be transmitted from one region to another. In the Metazoa, nervous conduction—the rapid transmission of signals from one part of the animal to another—seems to reside in cell membranes which can be partially or completely depolarized by chemical, mechanical, thermal, or electrical stimulation. Similarly, nonmuscular movement is exhibited freely by the protoplasm of many cells, even in that of differentiated tissues. Familiar cases include cilia, amoeboid movement, growth, and the stomata of plants. However, the contractility of the several types of muscle cells, like the capacity for nerve conduction, is of another and higher order of attainment, and it too was not attained in plants. Again, at the junction of nerve fibers with muscle and gland cells a few special secretions such as acetylcholine and epinephrine were evolved. These secretions transmit the nerve impulse from neurone to neurone and to the effector cells, muscle, or gland. Still other glandular secretions—the cluster of hormones—were also gradually acquired in this multi-fronted advance in animal organization; the quick or slow release of these versatile and powerful agents, whether in direct response to a change in the environment or to a neural stimulation, opened many paths to exceptional stance and performance and to the intrauterine development of mammals along with the many mental and social consequences of that type of reproduction.

A deeper meaning of the nervous and endoctrine systems of chordates rests on the circumstances that those systems there evolved as a single, united, superb regulatory and integrating mechanism. There, in chordates, self-maintenance proved itself compatible with the addition of new or much refined organs of special sense and with a brain whose localization and expansion were unimpeded by basic corporal architecture. In short, the chordate type became the path to that enlarged and more accurate perception of the environment and to that more effective responsiveness to it which cradled the superior mental act.

Through the development and full exploitation of the benefits derived from cooperating nerve, gland, and muscle—always aided or conditioned by organism's ever-growing

armory of gene-associated enzymes—some rare segments of the total animal world have evolved types of activity and behavior which are almost or quite as marvelous as the initially acquired property of self-duplication. These later, special, quite unique, and immensely superior animal attainments paved the way for the leisurely and progressive origin of the worthier behavior called "mental." Purpose and consciousness could arise only after its more eminent and more recent refinements; flight and instinct could arise after less elaborate integration; a simple reflex movement, useful but virtually detached from mentality, could precede all of that vast complexity except the modest differentiations of the nerve-net and the contractile cell.

The unity that characterized the simplest early organism was preserved in all that was attained later within evolving organism. Body, brain, and mind of elephant and man retain the status of functioning integers. Each of those units has a body-mind, not a body and a mind. The organism aware of self was the exceptional and relatively recent issue of immensely prolonged and sometimes inaccurate self-reproduction—followed always by rigorous tests for survival. No part of the spreading world of plants took steps in that direction. And only one of the few eminent animal classes of nearly a half billion years ago experienced the taking of several further steps towards self-awareness, thought, and purpose. Meanwhile, every step of that later vast advance—taken mainly by increasing and by exploiting the capacities of nervous, muscular and glandular tissues—was a tested and confirmed advance in the integration of the animal type of organism.

Though the trait of sociality appears at more than one level in the animal kingdom, it is the sociality expressed in the vertebrate series—more especially in the primates—that is of maximum interest. Preeminently in that series, from fishes to mammals, do the genic and endocrine foundations of broodiness or parental love exist and blend with those of sociality; in that group only are sociality, sympathy, love—all ingredients of altruism—assembled in a type of organism. Preeminently in the primates, endowed with prolonged intrauterine development, did the "family" unit of social life become established. In turn, in early man, family life became an environmental factor of first importance to his most outstanding performance; during a few hundred thousand years it provided him a favorable opportunity to develop language, and thus to open the door to abstract thought. Thereafter, the experience of one generation of selves could be communicated and added to that of later ones. Man himself then began the creation of culture and civilization—forces clearly beyond self, capable of shaping the aims and the destinies of nations and men, and providing the subject matter of the younger science of sociology.

Request for Papers

High school and college teachers who plan to attend the AIBS meetings at Oklahoma State, August 28-September 1, are invited to submit papers for possible inclusion in the NABT program to Mr. Phillip R. Fordyce, Oak Park-River Forest High School, Oak Park, Illinois. Title of paper must be submitted by May 1, 1960. Papers in the areas of teaching of invertebrate zoology in high school, teaching of genetics and probability, ecological studies, and promising laboratory techniques are especially solicited.

Educational TV

Managing Editor Muriel Beuschlein is on leave from the Science Education staff at Chicago Teachers College to work in the coordination of science in a service series seen daily over WGN-TV. On these telecasts she will concentrate on methods for teaching intermediate children using materials which are of interest to and frequently used by this group.

Yttrium

Clarence C. Grant of Rutgers University Agricultural Experiment Station described a method to detect the presence of yttrium in bone at a recent meeting at Seton Hall University. Yttrium-90, a strongly radioactive fallout product, is the "daughter" or decay product of strontium-90, a radioactive substance that can cause bone cancer. Yttrium-90 has a shorter half life than strontium-90, and the intensity of that radiation is considerably greater than that of strontium-90. Whether or not it has the bone-seeking tendency of strontium is not yet known.

To Sterilize: To Free from Disease Germs

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Fellow biology and health teachers, please note that the title definition does not delimit disease germs to actively reproducing forms; the definition states *disease germs*, which include spores.

The following appeared in the March 5, 1958 issue of SCOPE WEEKLY (4), "Use of the pressure cooker as sterilizer 'will eliminate the possibility of clostridial [tetanus] infections due to contamination of needles and syringes,' . . . ."[2] Johnson and Deasy of the Brisbane, Australia Health and Home Affairs Department, went on to say, "Nonsporulating organisms may be destroyed in twenty minutes of boiling at sea level, 'but spore-bearing organisms may survive. Indeed, some spores tolerate boiling for several hours.' "[4] Jean (1:279) supports this contention, "Spores may withstand hours of boiling or survive treatment with strong carbolic acid."[1]

A comparison between the *recommendations* for "sterilizing" by means of the three most common water-steam systems and actual *practice*, will, it is believed, indicate that we, as well as doctors and nurses, may be taking undue risks with materials assumed to have been sterilized.

The most common sterilization procedure used outside of hospitals is boiling in a hot water bath for twenty to thirty minutes. "Syringes used for injections and drawing blood and dissecting instruments are sometimes sterilized by boiling in water for thirty minutes."[5] One wonders whether *sometimes* refers to the frequency of the practice or the relative efficacy of the procedure. The answer may be found in a standard laboratory reference (regarding water bath sterilization): "This method is valueless for killing spores."[3] Kolmer and Boerner recommend boiling for *two hours*.

It would appear that the usual school laboratory and/or medical office practice of soaking contaminated objects in hot water is quite useless for destroying some kinds of spores. In this respect, the hardy and enduring nature of bacterial spores was explored in the April, 1956 issue of the ABT.[6]

The Arnold sterilizer, which uses steam not under pressure, is also misused when objects are steamed for twenty to thirty minutes in it. The recommendation for the Arnold-type sterilizer is: boil for twenty to thirty minutes and *repeat the procedure on the two succeeding days*.[5] Kolmer and Boerner are somewhat more cautious; they recommend for bulky material "forty-five to sixty minutes on each of three days in succession . . ."[3]

The autoclave utilizes steam under pressure and is commonly used in hospitals, rarely in office practice, and in school laboratories by those enterprising teachers who use pressure cookers. The U. S. Army[5] and Kolmer and Boerner[3] recommend sterilizing small objects in the autoclave at one hundred twenty degrees Centigrade (achieved at fifteen pounds of pressure) for fifteen minutes, and for large packages the time is increased to thirty to sixty minutes.

In looking back over these data one is impressed with the range of recommended temperatures and lengths of operating time. The water bath is generally used at temperatures approaching one hundred degrees Centigrade for thirty minutes. However, the recommendation is for one hundred degrees Centigrade for two hours in order to kill spores.

The Arnold-type sterilizer is usually used for twenty to thirty minutes. However, the recommendation is for forty-five to sixty minutes *on three days in succession*.

The most effective water-steam sterilizer is the steam under pressure type; i.e., the autoclave or pressure cooker, which achieves higher temperatures than boiling water and the recommendation for which is steam at one hundred twenty degrees Centigrade under pressure for fifteen minutes. Bulk media may well be re-autoclaved on two succeeding days.

In conclusion, it should be pointed out that our Australian colleagues referred only to tetanus organisms, but the principle of resistance of spores applies to other spore formers. It is obvious that spore formers require more than ordinary boiling water baths for their

extermination. Since spores are likely to be found anywhere, teachers should guard themselves against possible transfer of infection by following adequate sterilization procedures.

The original reading for this article was done four years ago when high school students raised questions concerning stitch infections and other allied, unexpected problems. While it is true that we could not come to any conclusion about a specific case, it is fair to generalize that finger and veni-punctures, injections, and sutures are surgical procedures requiring at least as much protection as autoclaving-pressure cooking can give.

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Cell Enzyme

A hardy enzyme that regulates the chemistry of all living things from microbes to man, called inorganic pyrophosphatase, withstands temperatures that destroy most vital living cell constituents, according to a man-and-wife team of microbiologists from the University of Mississippi School of Medicine, Jackson, Miss. In the body, the important substance regulates the formation of inorganic phosphate, a mineral essential to the life of a cell, report Dr. Emmett J. Johnson and his wife, Dr. Mary K. Johnson.

The enzyme owes its durability to the sturdy chemical bonds that hold its atoms together, according to the Johnson study. These bonds "provide a strong fortress against the forces of the environment, which all living things must resist in order to survive."

The enzyme studied by the two microbiologists was isolated from the bacterium *Azotobacter agilis*. The authors pointed out that "unicellular organisms, such as bacteria, offer an opportunity for study of the arrangement of this biological equipment, with the eventual hope of constructing a metabolic model of one of life's chemical workshops." This might be accomplished, they continued, "by locating the respective activities responsible for the daily chemical events of the cell, and then reconstituting the whole from its parts."

"Youth Looks at Cancer"

A new edition of this booklet is now available to the general public from your local unit of the American Cancer Society or the Society's national headquarters, 521 West 57th Street, New York 19, New York. It is a sixty-eight page, beautifully illustrated, and completely rewritten pamphlet concerning the biology of cancer. Biology teachers will find this a very handy reference to put in the hands of each one of their biology students.

Science Teachers Speak

Five hundred science instructors recently participated in a recent survey sponsored by the Scientific Apparatus Makers Association. Covered in the survey were questions on whether or not administrators conferred with teachers on new laboratories; administrators' attitudes toward released time and professional societies; and teachers' opinions of TV and audio-visual aids.

Copies of the complete report, "K-12 Science Teacher Opinions," are available without charge. Write Laboratory Equipment Section, SAMA, 20 N. Wacker Drive, Chicago 6, Illinois.

Fish Link in Evolution

Fishermen from Madagascar are reported to have caught and kept alive a coelacanth—a rare fish valued by scientists as a link in the chain of evolution.

The coelacanth lived millions of years ago. It has a distinctive armored head and the first land reptiles are believed to have evolved from this family.

"Beyond These Doors," an educational Science program will be seen during the second semester on Channel 11 in the Chicago area.

A Fundamental Biology Course for Eighth and Ninth Grade Pupils*

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The recent challenge of the scientific supremacy of the United States by Russia has resulted in an increased emphasis on science instruction at all levels as well as the scientific production of the United States. The increased concern about science has resulted in many recommendations and some changes in approaches used in science courses, content of science courses, and science curricula in the public schools. This increased emphasis in the public schools involves all phases of science: general science, biology, chemistry, and physics, as well as mathematics.

The shortage of mathematicians, physicists, and engineers has created a situation which has allowed physics and mathematics to gain some favor in high school curricula. This is manifested by the position in the curricula where biology is being placed in some high schools. There are some high schools where biology is being taught for a half year at the eighth and ninth grade levels, and this half year is likely to be the only high school exposure to biology that many boys and girls will receive. The half year of biology appears to be totally inadequate from the standpoint of time devoted and the needs of the pupils. In many instances it is questionable as to whether the approach is desirable for the maturity level of early teen-age youngsters. Some schools have reported that a ninth grade biology course is taught at a level which prepares pupils to take the advanced placement examination for college credit. A course which is taught at a level which prepares pupils for the advanced placement examination is essentially a college level course, and the content of such a course should be too advanced for eighth and ninth grade pupils. Since all of the other sciences are concerned with problems of man and his environment, and man is a biological specimen, it does not appear unreasonable for biology teachers to hold fast for at least a full year of fundamental biology at the eighth and ninth grade levels.

The approach to this first course should be fundamental and should appeal to the maturity level as well as academic ability of the pupils. One of the objectives of this course should be to motivate and stimulate the interest and curiosity of students so that they will continue to increase their knowledge in the field of biology after the first course has been terminated. This course should be treated in such a manner that the boys and girls can draw upon experiences from elementary and general science to better understand the biotic world of which they are a part. Caution should be taken to prevent the introduction of the complex biochemistry of metabolism of which eighth or ninth grade students do not have the chemistry background to fully understand. The class should be informed that the processes of metabolism are somewhat complicated and are not completely understood by experienced biologists. However, they should be told that they would understand more fully these processes if they take a second biology course after completing courses in high schol chemistry and physics.

This first biology course might well have its beginning with a review of climate and weather which influence the nature of the earth's surface and the distribution of plants and animals. The study of climate and weather might be followed by a study of the nature and composition of bodies of water and soil which serve to support plant and animal life. A discussion of media or environments of plants and animals should provide enlightening information on factors influencing the survival and distribution of organisms. In this fundamental biology course maximum use should be made of the biology of the immediate community. The first class exposure should be to living organisms and not of pickled specimens. The first approach is extremely important, for you want to impress upon the

*Presented at the NABT meetings with the AIBS at Pennsylvania State University, August, 1959.

students that biology is a science of life and should not be confused with the process of embalming which is concerned with preserving the dead. The approach used in this course should be largely ecological and evolutionary rather than taxonomic. Taxonomy or classification may be introduced as the student studies the ecology, morphology, and physiology of the organism. The taxonomy should be real and not artificial. Pupils should be encouraged to bring organisms into the classroom and to determine the phyla, classes, and orders to which they belong rather than to be forced to memorize the characteristics of a phylum, class, or order and randomly select representatives to be studied without any contact with a living or dead specimen. Planned field trips should provide students the opportunity to become acquainted with organisms which cannot be brought into the classroom.

The first biological specimen studied should be some plant or animal with which the students are very familiar. If the first specimen is a plant, the students might ascertain whether it grows from a seed and reaches maturity in a single season or whether it may persist for more than two seasons. If it grows from a seed in a single season, the problem of maintaining viable seed during periods unfavorable for growth may be considered in the perpetuation of this organism. This observation is possible even in the most urban communities, for pupils may note whether it is necessary to seed the lawn annually or plant flower seeds each spring. Problems concerned with seed germination should provide interesting experiences where students may employ the scientific method working with living biological specimens. Another observation may be concerned with the nature of the leaves of various plants, and also a macroscopic observation of the arrangement of the vascular bundles of plants bearing different types of leaves may be made. A further question which may be treated is the nutrition of familiar plants and of plants in general. Many practical demonstrations can be performed to supply first hand information to such questions. Another observation which might be made is whether the plant sheds its leaves annually or retains them. If the plant should retain its leaves some consideration should be given to the evolutionary features which make this retention possible. An explanation of shedding or retaining leaves should involve physiology, morphology, and evolution. By all means some consideration should be given to the importance of plants. Does the plant in question provide shade, provide protection for the soil against erosion, contribute to the discomfort of man, provide food and shelter for other organisms, particularly animals? Interesting information may be secured as to the state of health of the plant and, if it is not healthy, what are the agencies contributing to the diseased condition? Students should be confronted with questions seeking information as to the effect of certain diseases upon the population and distribution of plants native to America such as the chestnut and American elm trees. Attention should be given to the measures used to control plant diseases, particularly those used in the local community. Some consideration should be given to the means by which familiar plants in the community are propagated.

The study of variation among plants might provide a timely introduction to reproduction and Mendel's Laws. For the most part the treatment of heredity should be broad and general so that pupils may apply what has been learned when they begin to explore the animal life of their environment.

A good approach to the study of animals of the local community may begin with the investigation of animals associated with the plants studied. This type of introduction may very vividly impress upon the students the dependence of animals upon plants. Also, the approach to the animal kingdom should begin with familiar specimens. It might very well be a bird, a bat, a cat, a fish, an insect, or a worm. The general features of the organism might be noted and the individual placed into a phylum, class, or order. The examination of organisms to be studied later with similar features should be placed into the same or closely related categories. This type of approach should encourage boys and girls to classify other organisms which they have the opportunity to observe and handle.

A dynamic biology course should provide exploratory experiences as well as confirming exercises. The nutrition of familiar organisms should be treated, and in some instances students should be permitted to examine the materials in the digestive tract of a frog, a

bird, a bat, an owl, or some other animal of which the diet is not well known. The students might learn that some of the animals for which they have a dislike are friends of man.

Habitats and migratory habits of familiar organisms such as birds should be studied. An attempt should be made to associate migratory habits with such factors as day length, temperature, and reproduction.

This first biology course should provide general information on life processes of organisms including digestion, respiration, circulation, elimination, absorption, and reproduction. A study of the reproduction of plants and lower animals should certainly help the students understand and appreciate human reproduction when treated later in the biology course or in some other course. For the purpose of studying the significance of organs and systems in organisms, comparisons might be made between unicellular organisms, such as *Euglena* and *Chlamydomonas*, and multicellular organisms, such as bean plants and frogs; these organisms can be handled very easily in the laboratory. A brief examination of the beating of a frog's heart will probably leave a longer impression of the study of circulation than any fancy chart or model. It was reported in the July 13, 1959, issue of the "New York Times" that one of the fifty-seven high school students in a National Science Foundation program at Rutgers University was, "a sixteen-year old boy, who aspires to be an engineer and whose interest had been far removed from poultry science became enthusiastic the other day as he told of helping to measure the cardiac functions of a chicken." With the use of a living animal in the study of circulation, you have a springboard which may invoke questions which, when answered, will contribute to the pupils' knowledge and understanding of this vital process.

This basic biology course should not be presented in a manner which shows a strong dichotomy between zoology and botany. It should be emphasized that with few exceptions the same vital processes take place in both plants and animals. In this paper it has been suggested that plants might be considered first; however, every opportunity should be taken to use the integrated approach studying plants and animals at the same time whenever possible. Also, living or recently collected specimens should be studied whenever available.

The content of the eighth or ninth grade biology course which has been recommended is not rigid or a "must" in any curriculum or general biology course. The approach does appear desirable. Some schools are using at present an approach of this type. Summer biology camps for high school students are conducted in some communities where boys and girls have the opportunity to make use of an outdoor laboratory and to study plants and animals in their natural habitats. During the summer, schools in urban communities might give serious consideration to offering a biology course of the type which has been discussed at a time when outdoor laboratories are accessible and contain a wealth of biology to be explored.

A full year of fundamental biology is recommended for all students at the eighth or ninth grade level. The experience of this course should be extremely meaningful to the boy or girl who does not continue his high school training. It should provide him with an appreciation and understanding of his biotic world and enable him to derive rewarding experiences from the wonders of nature. To students who continue their high school experience, it should motivate them to take a second biology course after they take courses in chemistry and physics. The first biology course may encourage or direct students into high school chemistry and physics classes so that they may get the necessary background to understand and appreciate an advanced high school biology course.

There are many biology teachers who are of the opinion that high school biology should not be taught below the tenth grade level; however, each year more schools are offering biology at the eighth and ninth grade levels. The level at which biology is taught should be governed by the students involved and the program of the school. However, if biology is offered below the tenth grade level the approach to this course should be designed to suit both the maturity level and academic ability of the students involved.

NABT now boasts of the largest membership in its history.

Strontium-90

Contamination of food by radioactive fallout from nuclear explosions is greater in the Amazon Basin than in the United States, where there is five times as much fallout. The concentration of strontium-90, considered the most hazardous form of atomic debris, is generally three times as high in the United States and other areas in the same latitude as in the Southern Hemisphere, but unusual weather conditions enter into the picture in the Amazon, according to Dr. Arthur R. Schulert, staff biochemist of Columbia University's Lamont Geological Observatory, Palisades, N. Y.

In general, cereal grains contain the highest levels of strontium-90, some fruits and vegetables contain intermediate levels, and milk has the lowest level, although there are large variations within each group, the biochemist said.

In the Amazon Valley the heavy tropical rainfall brings strontium-90 down from the upper atmosphere, he explained. Over the years, it also has washed some of the calcium out of the soil. Both factors tend to increase the strontium in food crops and milk, because strontium is chemically related to calcium and tends to replace it in crops and in bone structure, especially when calcium levels in the soil are low.

If the amount of strontium-90 in the average diet in the United States remained at its present level, it would ultimately produce radioactivity in the body amounting to 5 per cent of the radiation we now receive from natural sources, Dr. Schulert commented. The fact that it is much lower than this indicates that there is a considerable time lag in the absorption of strontium-90 from food into the bones.

"The dissemination of strontium-90 throughout our environment as a result of nuclear explosions has been under extensive investigation for the past several years," Dr. Schulert said. "It is generally considered the most hazardous isotope present in nuclear debris because of its long half-life (28 years) and the fact that it is similar to calcium and finds its way into foodstuffs and ultimately into human bone.

"Food is the key point in the transfer of strontium-90 from bomb to bone. Strontium-90 produced at detonation travels through the atmosphere to the soil, then into plants and on into humans either directly or through dairy products. An understanding of the steps in this chain is necessary if we wish to explore means by which the incorporation of strontium-90 into the human body might be reduced.

"Food is the only means by which bone concentration may be estimated with reasonable accuracy in remote, but nevertheless important, geographic areas. However, once the body's take-up of strontium-90 from food is known (and this has now been established within reasonable limits) the bone levels in any group of people can be predicted from their dietary levels.

"Food is the best 'barometer' for quickly assessing potential danger to man. The bone mineral of the body is replenished very slowly. Consequently it takes a considerable time for a sharp increase of strontium-90 in one's food to be reflected in overall bone concentration. Clearly food, and not bone, is the item to be watched in order to keep abreast of changes in the strontium-90 picture as it affects man.

"The concentration of strontium-90 in food is primarily a function of the local fallout, the nature of the soil, the type of food and the agricultural practices used in food production. In terms of 'Sunshine Units' (a Sunshine Unit is a minute amount of radiation equal to a micromicrocurie of strontium-90 per gram of calcium), the average U. S. content in cereal grains is 20, in some fruits and vegetables 12, and in milk 8 units.

"A sizable fraction of effort both in our laboratory and others has been directed toward investigations in milk, since milk and other dairy products constitute the major source of dietary calcium in the United States, even for adults. The highest value yet noted was 36 Sunshine Units, found in the northern Great Plains area. Since this sample represented the pooled milk from a large number of farms, there are no doubt individual farms in the area exceeding 40 units in their milk, and perhaps reaching 50.

"The highest level of strontium-90 in any food thus far analyzed was found in food from the tropical rain forest of the upper Amazon Basin. Some values found here exceed 40 Sunshine Units."

Film

"Balance in Nature," a 17-minute, 16 mm. sound movie in color, produced by Robert H. Crandall, portrays the life cycles of aphids and their enemies, ladybird beetles. It is being distributed by Filmscope Inc., Box 397, Sierra Madre, California, for $170.

Book Reviews

THE BESTIARY, A BOOK OF BEASTS, T. H. White, 295 pp., $1.45, G. P. Putnam's Sons, New York, 1960.

A delightful book, full of fact, fancy, fable, and moralizing. The author gives us a free translation of a Bestiary produced in the 12th century. About 150 animals are included. For each there is typically an explanation of the meaning of the name—usually erroneous, miscellaneous bits of information, and often a moral lesson. Thus: "HRYCUS the He-Goat is a lascivious and butting animal who is always burning for coition. His eyes are transverse slits because he is so randy. It is thence that he gets his name, for the Hyrci are slit-eyed too, according to Suetonius."

Following the description of the Ibis we have this: "Now if the sun and moon do not throw out their cruciform rays, they do not shine: if the birds do not spread their wings like a cross, they cannot fly. Just so, Man, if you do not protect yourself by the sign of the cross and spread your yard-arm wings of love, you will not be able to go through the tempests of this world to the quiet haven of the heavenly land."

The illustrations, copied from the manuscript, and the author's comments and explanatory appendix add much to the pleasure of the reading. The book has no plot, of course, and one reads it piecemeal when one has a few spare minutes. There is a good bibliography and index.

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PRINCIPLES OF PALEOBOTANY, Second Edition, William C. Darrah, 295 pp., $6.50, The Ronald Press Company, New York 10, New York, 1960.

This edition follows 20 years after the appearance of the first edition. The author's stated goal is to provide a general survey of fossil plants for the nonspecialist. The book is intended for use in a one-semester college level introductory course in paleobotany, as well as for supplementary reading in courses in plant evolution, morphology, and phylogeny.

Much new information is presented as a result of greatly-increased paleobotanical research during the past two decades. Twenty-three chapters are included, each with a fairly complete and up-to-date bibliography. Numerous illustrations of reconstructions of fossil plants and extinct floras of past geologic periods are features which add considerably to the merit of this edition.

WAVES AND THE EAR, Willem A. Van Bergeijk, John R. Pierce, and Edward E. David, Jr., 235 pp., $.95, Anchor Books, Doubleday & Company, Inc., Garden City, New York, 1960.

This is one of the paper-back monographs being issued by the Physical Science Study Committee. It is interesting to see that of the four books produced, at least two are biology oriented. This is one. While several good treatments have appeared recently on this topic, this will be an admirable, inexpensive, work to which students may refer. It deals with the mechanics of sound transmission and the biology of reception, as well as the theory of waves themselves. While this is meant for the student of physics, biology teachers interested in the topic will find it an interesting treatment which students will be able to read easily.

P. K.

ALGAE IN WATER SUPPLIES, C. Mervin Palmer, viii + 88 p., $1.00, Public Health Service Publication No. 657. Supt. Documents. Washington 25, D. C., 1959.

This new illustrated manual provides an economical guide to some of the fresh water algae. Written for water-plant operators, most of whom lack the technical training needed for precise taxonomic work, this manual can be used by the teacher and his students for the approximate identification of many of the fresh water algae. The appendix includes a key to over 250 species. The six colored plates show about half this number, and there are numerous line drawings in the text. The colored plates are quite beautiful and should stimulate student interest and facilitate identification. They do not show structural details, and unfortunately the species shown on individual plates are drawn to different scales. The scales are given in the legend.

The chapters on various aspects of the economic importance of algae in water supplies are written so an intelligent student can read them with profit. They may well stimulate him to undertake individual projects, and the references at the end of the chapters will provide sources for further reading.

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EVOLUTION AND CHRISTIAN THOUGHT TODAY, Russell L. Mixter, 224 pp., $4.50, Wm. B. Eerdmans Publishing Company, Grand Rapids, Michigan, 1959.

An interesting attempt to reconcile current evolutionary and genetic theory with the principles of theology held by the so-called "evangelical" Christians. Throughout there are rather clear statements of evolutionary and genetic thought and evidence. However, every ambiguity and contradiction is eagerly pounced upon, and no opportunity is ignored to point out that the *main* ideas of evolution and genetics do not contradict fundamentalist Christian theology. There is no attempt to deny the evolutionary origin of species or the possibility of "artificial" creation of life. However, the reconciliation of the evidence and creationist theology on the origin of man does not come off well.

P. K

MANKIND IN THE MAKING, William Howells, 382 pp., $4.95, Doubleday & Company, New York, 1959.

One of the neglected areas in secondary schools, existing in the "No-Man's Land" between biology and the social studies, is physical anthropology. This book is an excellent effort by a distinguished anthropologist to put the findings of this science into an easily readable form for student and teacher. The arrangement of the book is an introductory set of chapters on evolution, and vertebrates, mammals, and primates, followed by a series of historical sketches on the discovery and significance of various skeletal materials, and concluded by chapters on the various races. The author uses an easy style with many references of a personal nature to the prominent anthropologists who have made the important finds of skeletal material of human and sub-human remains. All of this wealth of evidence is then used to piece together a probable explanation of man's past with